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E. A. Lappo
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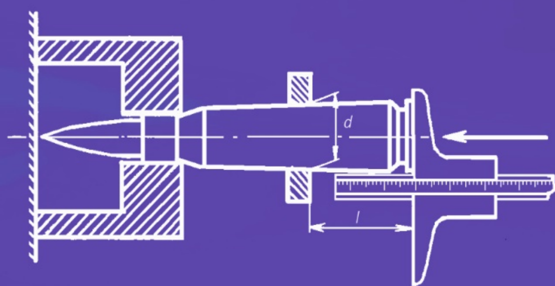
FORENSIC RESEARCH CARTRIDGES (AMMUNITION) FOR HAND-HELD SMALL FIREARMS



Mogilev
2020

THE MINISTRY OF INTERNAL AFFAIRS OF THE REPUBLIC OF BELARUS

Educational institution
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of the Ministry of Internal Affairs
of the Republic of Belarus»

E. A. Lappo, A. S. Rubis, M. A. Litvina

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FORENSIC RESEARCH CARTRIDGES (AMMUNITION) FOR HAND-HELD SMALL FIREARMS

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The monography presents the issues of theoretical and legal, organizational and methodological support of forensic ballistic examination of cartridges (ammunition) used for shooting in hand-held firearms.

This publication can be recommended for use in the educational process by students, cadets and students of higher education institutions of legal profile, in the practice of employees of expert departments, operational staff, investigators, prosecutors and judges.

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КРИМИНАЛИСТИЧЕСКОЕ ИССЛЕДОВАНИЕ ПАТРОНОВ (БОЕПРИПАСОВ) К РУЧНОМУ СТРЕЛКОВОМУ ОГНЕСТРЕЛЬНОМУ ОРУЖИЮ

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INTRODUCTION

One of the priority areas of law enforcement is the fight against illicit trafficking in small arms fire-strelnogo weapons, ammunition (ammunition) used for shooting from it. Improving the design of hand-held small arms, the invention of unitary cartridges (ammunition) allowed to increase its tactical and technical characteristics and striking properties. At the same time, the ability of the criminal community to flexible transformation, depending on changing external factors, has a stable tendency to its increasing armament, the use of advanced science and technology, which makes it necessary to improve the efficiency of law enforcement and expert practice.

The production of cartridges (ammunition) used for shooting from handheld small arms as products of mass production causes their entry into illegal circulation through various sources (theft in military formations and paramilitary organizations, sports organizations; from persons engaged in hunting, etc.), in which there is a significant amount of these objects, complicating control over their use.

Despite the fact that information on the number of cartridges produced by enterprises belong to the information of limited access, the volume of production of cartridges (ammunition) can be judged by the following published data: in 1944, enterprises of the USSR produced 7.4 billion cartridges of various calibers [93]. Currently, in the Russian Federation, the production of cartridges is carried out at several enterprises, one of which, specializing in the production of cartridges for combat, service and civil weapons of various calibers, has a design capacity of 500 million rounds per year, the productivity of only one line of complex automated production with a full technological cycle is 1.000–1.200 rounds per minute.

In the current situation, the role of forensic ballistic examination is indisputable, in the framework of which the expert study of the indicated objects is carried out. At the same time, an important condition for improving the effectiveness of criminally significant recommendations is the increment of new knowledge, taking into account specific situations in the practice of both law enforcement agencies, expert units, and prosecutorial bodies, the court in assessing the reliability of the conclusions contained in the expert's conclusion.

Recently a number of scientific directions and theories have appeared in forensic science and forensic ballistic examination. Nevertheless, the analysis of domestic and foreign literature indicates that developments in the field of forensic research of cartridges (ammunition) are usually applied and are considered by scientists in relation to a specific type of expert tasks. The lack of a unified methodological approach to the study of the nature of such crime categories as "patron" and "munition", bringing in forensic science definitions of these terms from related Sciences (military, technical, etc.), the use of different grounds in developing classifications of cartridges (ammunition) led to a lack of clear understanding and uniform application in forensic work and law enforcement.

These circumstances do not contribute to the development of the theory of forensic ballistic examination of cartridges (ammunition), reduce the validity of the results and the reliability of expert conclusions. Based on the fact that the purpose of forensic ballistic examination is to establish the nature and properties of the object of study, i.e. the facts that are essential for establishing objective reality, the conclusions and recommendations obtained in the course of such activities have undoubted significance and relevance.

The authors attempt to resolve key issues in this area, including those related to the content of basic terms and their definitions, the construction of the classification of cartridges for various purposes, not only on the basis of existing scientific ideas, but also taking into account the practice of expert research in the Republic of Belarus and the Russian Federation.

It should be noted that in the field of forensic ballistics, certain theoretical provisions have been developed, considerable practical experience has been accumulated in the production of expert examinations of cartridges (ammunition), which requires a comprehensive analysis, systematization and generalization. At the same time, there is no uniform understanding and application in forensic activities of some terms and their definitions contained in the scientific forensic literature and legislative acts; the criteria for classifying cartridges of hand-held small arms as “ammunition” are not clearly established»; existing classifications are characterized by incompleteness of the applied bases; the latest achievements of natural Sciences are insufficiently applied in the forensic study of these objects.

The theoretical basis of this study composed the works of Belarusian, Russian and Ukrainian scientists:

in the field of criminalistics and forensic examination — T. V. Averyanova, R. S. Belkin, A. I. Vinberg, A. V. Dulov, V. F. Ermolovich, Yu. G. Korukhov, E. R. Rossinskaya, A. S. Rubis, A.V. Sonis, V. P. Shienka and others.;

in the field of weapons studies and forensic ballistic research — A. G. Andreev, V. S. Akhanov, D. A. Burya, A. G. Egorov, B. N. Ermolenko, A. I. Kaledin, A. V. Kokin, V. Ya. Koldin, B. M. Komarinets, D. K. Koretsky, S. D. Kustanovich, A.V. Lapin, I. V. Latyshov, V. M. Pleskachevsky, O. V. Miklyaeva, V. A. Ruchkin, L. F. Safran, A. V. Stalmakhov, E. I. Stashenko, E. N. Tikhonov, A. I. Ustinov, V. A. Fedorenko, V. F. Chervakov, S. V. Yatsenko, etc.;

in the field of forensic medicine and wound ballistics-N. I. Pirogov, V. V. Boyarintsev, S. S. Girgolava, E. K. Gumanenko, E. A. Dyskin, L. E. Kuznetsov, L. B. Ozeretskovsky, V. L. Popov, V. B. Shigeev, etc.;

in the field of military Sciences (internal and external ballistics, design and application of small arms, ammunition) — A. A. Blagonravov, V. G. Fedorov, I. A. Balagansky, V. A. Grigoryan, G. A. Danilin, V.N. Dvoryaninov, V. M. Kirillov, V. P. Ogorodnikov, V. M. Sabelnikov, M. E. Serebryakov, A. A. Taskina, P. N. Shkvornikov, etc.

The monography identifies specific ways of improving the process of forensic investigation of bullets (ammunition) in obtaining forensically relevant information about the properties of their design; establish criteria for assessing lethality; determine the basis for the construction of the classification of these objects; development of practical recommendations on improvement of methodological support of expert research rounds (ammunition) for small arms.

Chapter 1
RETROSPECTIVE ANALYSIS OF THE IMPROVEMENT OF DESIGN ELEMENTS OF CARTRIDGES (AMMUNITION) FOR HAND-HELD SMALL ARMS, GENESIS AND DEVELOPMENT OF SCIENTIFIC IDEAS ABOUT THEIR FORENSIC RESEARCH

The issues related to the expert study of cartridges (ammunition) used for firing modern small-arms firearms, it is important to consider first of all in the historical aspect, taking into account that "… the scientific study of phenomena and processes cannot limit itself to their state at the moment of 'available' existence, since the causal relationship in the historical development will be lost" [88, p. 110].

S. N. Tregubov in 1912 pointed out that "colossal advances in technology…, enriching modern humanity with various inventions, discoveries and improvements…, at the same time, they had a noticeable but, unfortunately, harmful effect on the external manifestations of crime…" and "rapid-fire weapons and smokeless gunpowder…, advances in chemistry, bacteriology, etc. — all this, along with the benefits brought to humanity, contributes to the refinement of the execution of criminal plans and the elusiveness of the perpetrators" [263, p. 7].

As noted by V. A. Ruchkin, "… the design and combat characteristics of the weapon are largely determined by the linear-weight, structural and other features of the cartridge" [227]. For design patrons (ammunition), used for called the shots from manual rifle firearms, with moment their the emergence of until now time characteristically a permanent improving, associated in including with historical development manual rifle firearms in a whole with perspective raising his efficiency and reliability functioning.

The study of the process of creating and improving the design of cartridges (ammunition) used for shooting from small arms, their impact on the practice of forensic research should be carried out taking into account the historical development of both their design as a whole and its individual elements, since the identification of objective patterns should be due to an adequate reflection of reality, disclosure of the essence of the studied reality, explanation of facts, phenomena and processes. Based on the integrative-historical approach and historical methods of research of most of the studied phenomena, it is possible to conduct specialized research in depth due to a more reasonable interpretation of the results.

Thus, in the study of the problem of forensic investigation of cartridges (ammunition) used for shooting from small arms, it seems reasonable to consider not only the historical aspect of the origin and development of forensic ballistic examination of these objects, but also the evolution of their design from the point of view of military and technical science.

The most important factor that influenced the evolution of cartridges (ammunition) and small arms as a whole as an object of material culture is the invention of gunpowder — the first propellant explosive, which later became an integral element of the design of cartridges (ammunition). With the invention of gunpowder to replace cold and throwing weapons, using the muscular power of man, came firearms, using the energy of gunpowder gases, which had a number of previously unattainable properties and qualities, the main of which-increasing the range of fire and the striking ability of the wounding projectile. Analysis of historical sources shows that the original improvement of firearms was due to the needs of its use in the military. According to historians, gunpowder invented in the IXth century in China, and then spread to Europe and Asia. By the end of the XIIIth century the first artillery guns were constructed in China [87, p. 13].

In the lands corresponding to the territories of modern Belarus and Russia, firearms appeared almost simultaneously — in the 80th of the XIV century. So, in 1383 it was used by the army of the Grand Duchy of Lithuania during the siege of Trok castle [26, p. 213]. In the chronicle sources indicate that during the campaign of Prince Vytautas with the crusaders on Vilna in 1391 "many Lithuanians and Germans beaten by cannons" [209, pp. 125–126]. In 1393 Prince Vytautas used cannons in the siege of Vitebsk, occupied by the rebellious Prince Svidrigaila [209, p. 235].

The first mention of the use of firearms in the Moscow state during the siege of Moscow by the Tatars dates back to 1382, when Khan Tokhtamysh with a large army besieged Moscow. The townspeople three days successfully repelled the attack of the Horde with the use of light cannons ("pallets") and, obviously, cannons of a larger caliber. "When the Tatars approached the walls of the city, then the inhabitants of the city, resisted them, shot arrows and stones, the allies helped in the defense of pallets, crossbows, resembling harquebuses, as well as large cannons" [210, p. 130].

Manual small arms firearms appeared as a result of the evolutionary development of artillery weapons, in particular cannons. Initially the barrels of guns and rifles were made of wood, because the technology of making them out of metal was not yet finalized. So, in 1596, a wooden gun was used in the battle of Gulsen (Holland), in 1624, a mortar made of a wooden stump was fired at the city of Cleves [182, p. 50].

In the initial period, muzzle-loading hand-held small arms had a low rate of fire, and the kinetic energy of bullets corresponded to the energy of arrows fired from a crossbow, due to the small amount of obturation (i. e., ensuring the sealing of the barrel of firearms when fired, preventing the breakthrough of powder gases) between the bullet and the walls of the barrel. To eliminate this disadvantage, after filling the gunpowder in the barrel channel, a wad made of tow, leather, bast or other soft materials was placed on it, then a bullet was sent to the barrel channel by blows of the ramrod [55, pp. 60–62].

To increase the rate of fire of small arms in 1530 in Spain, a paper cartridge was invented, consisting of a paper sleeve, a powder charge and a bullet. This increased the convenience of loading, since the mass of the powder charge was pre-selected to the gun, provided its protection from external influences (moisture), and the shell of the cartridge was used as wad. This innovation has significantly increased the rate of fire of small arms, which subsequently led to the spread of paper cartridge throughout Europe [157, p. 44]. In particular, in Russia, in the ammunition of Ivan The Terrible Sagittarius army to increase the rate of fire and ease of loading appeared zaryadtsy (cushions with a powder charge), similar in functional purpose to a paper cartridge [154].

Initially, all samples of firearms were loaded from the muzzle of the barrel, but already in the XIV–XVI centuries. Attempts were made to load from the breech of the barrel. Breech-loading small firearms consisted of a barrel and a separate charging chamber that is inserted into the barrel and secured by a special wedge, but in this period, this loading system have not been spread because of imperfection of technology of locking node and the dangers of breakthrough powder gases in the shooter's direction [271, p. 12].

In order to facilitate the loading of hand-held small arms from the muzzle of the barrel since 1498, rifling (initially straight) began to be made to embody the idea of the Austrian gunsmith Gaspar Zollner. Various constructive ideas, perceived and in modern designs manual rifle firearms, originated in the XVI century. Thus, in the works of Leonardo da Vinci (1500), Lorini (1579) contained drawings and sketches of the outer surface of the barrels equipped with piston and wedge gates and had a helical thread to ensure the stability of the flight of oblong projectiles, but the spread of these structures inhibited as the General state of technology, and the difficulties associated with the need for precise machining and low level of development of metallurgy [286, p. 13].

With the advent of screw rifling, the firing range of hand-held small arms increased to 600 steps by giving the bullet gyroscopic stability as a result of rotation, increased accuracy, accuracy and accuracy of the trajectory. However, the inconvenience of loading did not allow widespread use of such weapons. The situation changed dramatically only by the end of the XIX century after the transition to charging from the outer surface of the barrel and the invention of the unitary cartridge [157, pp. 37–38].

The transition from a muzzle-loading hand-held small-arms firearm to a breech-loading barrel and the creation of a unitary cartridge with a metal sleeve was made possible by the discovery of initiating explosives, as well as the replacement of smokeless powder with smokeless. The inventor of the initiating explosive, mercury fulminate, is not known for certain ($Hg(CNO)_2$), but the first mention of it are found in literary sources of the beginning of the XV century, in particular in the "Book on pyrotechnics" (Feuerwerksbuch). In the manuscript of Basil Valentine (Basilius Valentinus), dating from the first half of the XVII century, also contains a mention of "rattling gold", discovered by the Dutchman Cornelius van Drebbel. The first presentation of the process of manufacturing mercury fulminate belongs to the German chemist I. Kunkel (1690). Attempts to invent friction and shock initiating explosives were made by the French scientist P. Bolduc (1700). The capsule in an iron cap with mercury fulminate of the open type is invented by the American D. Shaw in 1814 [55, pp. 163–164].

By the beginning of the XVIII century. with the advent of gremuchertutnogo capsule-igniter, the idea of creating a so-called unitary PA-throne (from lat. unitas-unity), the design of which allowed using the sleeve to combine the charge, the projectile and the primer-igniter. In 1812, the French gunsmith S. I. Poly patented a the outer surface of the barrels rifle and a unitary cartridge, the sleeve of which was made of metal on a lathe; in 1814 he also invented a cartridge, the initiating composition of which was ignited by compressed air [157, p. 137]. However, the proliferation of these structures of ammo and small firearms is not received.

By 1829, the German gunsmith I. N. Dreise invented a unitary cartridge with a paper sleeve for a needle rifle of his own design. As a result of the shift from loading of the cartridge from the barrel to the principle of loading from the breech and use the unit lock the sliding bolt from turning was provided an acceptable level of obturation. In 1840 the needle gun of the Dreise system under a unitary cartridge with a paper sleeve was adopted in Prussia, in 1868 the needle gun of the Carle system was adopted in Russia. However, in the 70s of the XIX century. This sample was replaced by systems using a unitary cartridge having a metal sleeve, the design of which is close to modern [39, p. 319].

In 1842, the French gunsmith L. Flaubert invented a unitary hornless cartridge with a solid copper sleeve, improved in 1856 by B. Beringer by placing a charge of gunpowder in it [157, p. 139] (note that the cartridge (ammunition) of this design (.22 Long Rifle) is used without any changes up to the present time in sports and hunting rifled firearms).

English gunsmith C. Lancaster in 1852 invented a new design of the cartridge, in which the ignition of the powder charge in the sleeve was carried out through the seed holes. The introduction of in pillar patron a metal thimbles contributed to the final addressing problems breakthrough gunpowder gases under loading with breech parts of trunk and transition to designing mnogozaryadnykh weapons systems, in particular create rifles with longitudinally-sliding the bolt. This, in turn, led to the abandonment of muzzle-loading hand-held small arms and the reduction of the barrel caliber to 11–13 mm [202, pp. 7–8].

During this period attempts were made to improve the combat characteristics of handguns with rifled bore and ease of loading by changing the shape of the bullet. In the transition to weapons with rifled barrel on the surface of the bullets, which originally had a spherical shape, began to make projections, repeating the elements of the cross-section profile of the barrel. In 1846, the British General W. Jacobs proposed an oblong bullet with four leading protrusions, which increased the range of fire and piercing effect of bullets of hand-held small firearms [55, p. 195]. In 1864, the Englishman J. Whitford, having conducted a series of experiments related to the study of the effect of rifling the barrel and the shape of the bullet on the results of shooting, received a patent for a hexagonal bullet oblong shape of its own design. The accuracy of the specified type of bullets at a range of 450 m was 7.7–10.7 cm from the center, while the best result for this distance at the time was 64 cm [55, pp. 200–201]. This served as the basis for the development of new types of bullets for hand-held small arms (cylindrical (oval), pointed and blunt-pointed forms). By 1860, Austria had developed bullets for 13.9-millimeter guns that contained explosives [55, pp. 207–208]. Besides, cartridges with a buckshot shell, incendiary bullets with a pyrotechnic mix which at hit in a body were destroyed were created and caused extensive damages (in 1868 their use against the person is forbidden by the international agreement "about cancellation of the use of explosive and incendiary bullets" concluded in St. Petersburg) [211, p. 34].

In the period under review as the main means of ignition of the powder charge in the cartridge was used gremuchertutny capsule. However, in 1870 in France, an "electric" gun was invented, in which the ignition of the powder charge was carried out by an electric method from a galvanic battery placed in the butt of the gun; later, the Belgian gunsmith G. Pipper created a gun of a different system, used as a hunting gun [157, p. 281]. Currently, this method of ignition has found application in the design of the cartridge (ammunition) 4,7×33, used for shooting from an automatic rifle Heckler & Koch G11 [56, pp. 193–210], and also cartridges (ammunition) 18×55T to firearms of traumatic action [199; 297], individual designs of homemade hand-held small firearms [155].

Until the middle of the XVIII century. the main type of gunpowder remained smoky. M. V. Lomonosov made a significant contribution to the production of gunpowder in Russia. After a series of experiments with different compositions of gunpowder, he chose the most optimal ratio of the components of the powder mixture-potassium nitrate, charcoal and sulfur, which remains unchanged to the present time. The result of these experiments were also scientific works of the scientist —"Thesis on the birth and nature of saltpetre" and "On the nature of gunpowder". The main problem of production of large volumes of gunpowder was the lack of potassium nitrate, attempts to replace it in the composition of gunpowder with other substances were not successful [249].

At the end of the XIX century, pyroxylin (cellulose nitrate) was proposed to replace smoky gunpowder, which has a number of significant drawbacks. however, being a powerful explosive, it could not be used as a propellant charge in its pure form. French engineer P. Weil in 1884 plasticized nitrocellulose in a mixture of alcohol and ether, as a result of which smokeless gunpowder was invented. Depending on the plasticizer used, different grades of smokeless gunpowder with certain properties are obtained [292, p. 273].

In Russia experiments with pyroxylin were carried out in 1845 by the artilleryman A. A. Fadeev. However, the unstable properties of the resulting pyroxylin during storage (in particular, self-ignition) and the combustion close to explosion in the barrel channel of small arms firearms did not allow it to be used as a propellant explosive Burning [55, pp. 375–376].

In connection with the adoption of the French troops in 1886 of the Lebel rifle in Russia, work on the production of domestic smokeless gunpowder was intensified with the participation of scientists, including D. I. Mendeleev [150], who noted: "Smoky gunpowder was found by the Chinese and monks-almost by accident, by touch, by mechanical mixing, in the scientific darkness. Smokeless gunpowder is discovered in the full light of modern chemical knowledge" [160, p. 47].

G. A. Zabudsky, Z. V. Kalachev, S. V. Panpushko, A.V. Sukhinsky, N. P. Fedorov also made a significant contribution to the production of smokeless gunpowder in Russia. The high level of secrecy at the French plants did not allow to establish the necessary technological reagents; at the Vetturen plant in Belgium, A.V. Sukhinsky literally "by smell" determined the use of ethyl acetate in its production [278].

By the early twentieth century. in the world was established the production of several types of smokeless gunpowder, of which the most common were pyrocollodium powder D. I. Mendeleev, pyroxylin powder P. Viel, as well as powder mixture-cordite.

The use of smokeless gunpowder in the design of cartridges (ammunition) would be impossible without appropriate scientific justification and means of measuring the internal and external ballistic parameters of the shot. If initially rules and receptions waging called the shots from ancient throwing machines were based on results, forestry by practical experiences, then to mid-the eighteenth digits thanks to scientific writings J. L. Lagrange, I. Newton, B. Robins and L. Euler in ballistics have become be used achievements mathematics, physics and chemistry.

The analysis of literary sources testifies that at the end of XIX — the beginning of XX century the design of cartridges of manual small arms firearms was based on the requirements theoretically proved by military science to such ammunition. As noted above, this was due to the progressive development of scientific and technological progress, primarily in the field of natural Sciences.

For mass weaponry army needed unified samples manual rifle firearms, with a certain stability such characteristics, as ensuring monotonous speed by air bullets, constancy properties gunpowder weapons and others. It is the need to comply with these conditions that led to the active use of the achievements of natural Sciences in the development of samples of hand-held small arms. The principles of research of parameters of manual small arms, methods of production of measurements, originally developed within the framework of classical mechanics, supplemented by scientists in the field of military Sciences, subsequently began to be applied in forensic activities.

The idea of transforming the motion of a small projectile with high velocity into the motion of a body with high mass but low velocity was used in the study of bullet motion by the French astronomer J. Cassini in 1707 [68, p. 42]. In 1740, B. Robbins created a ballistic pendulum, which made it possible to more reliably determine the initial velocity of bullets fired from small-hand firearms. L. Euler, developing the ideas of I. Newton and B. Robins, in the works "New Foundations of Artillery" "On the Power of Gunpowder", "On the Impact of Bullets When Firing on the Board" attempted to scientifically substantiate empirical data in the field of ballistics [294], J.-L. Lagrange in the work "Analytical Mechanics" completed the mathematization and generalized the empirical material accumulated by this time in classical mechanics, which contributed to the use of this area of knowledge in ballistic research.

The development of ideas about the internal and external ballistics of hand-held small arms, the emergence of new measuring instruments allowed to determine with the necessary accuracy the internal and external ballistic parameters of the shot. In more detail the development of tools and methods of expert measurements will be discussed in section 3.2 of the monography.

The Russian school of experimental ballistics was founded by N. V. Mayevsky, who in his work "On the Influence of Rotational Motion on the Flight of Oblong Projectiles in the Air" (1865) determined the directions of its further development. N. A. Zabudsky for the first time in the world theoretically justified the method of calculating the steepness of rifling required to ensure the stability of a rotating bullet in the air. The primacy in the use of electricity to measure the speed of projectiles and bullets belongs to K. I. Konstantinov, who in 1842 invented the electric chronoscope, in 1843 — electromagnetic pendulum chronograph, in 1844 — electroballistic chronograph [290, pp. 12–22].

These achievements in the production of measurements of ballistic processes occurring when fired, allowed not only to move to the use of smokeless gunpowder as a propellant charge used in the design of ammunition cartridges, but also to provide scientific justification for other parameters of hand-held small arms in its design and application to the target.

The lower rate of combustion of smokeless powder compared to smoky, as already indicated, allowed to achieve a higher bullet velocity with a smaller mass of powder charge. However, at the same time, the lead bullet, acquiring a greater speed in the barrel channel, received a significant deformation in the process of firing. The solution to this problem was the appearance of shell-type bullets, in which the lead core is enclosed in a shell of copper or Nickel silver, which performed the function of "solid" lubrication, which led to a decrease in the caliber of firearms to 7–9 mm, as well as the appearance of multi-loading and automatic hand-held firearms [202, p. 9].

As a result of ballistic studies and scientific research by scientists in Germany (A. Gleinich), Russia (G. P. Kisnemsky), France (Desalle) since the early 90th of the XIX century. the armies of these countries began to accept rifle cartridges with a pointed shell bullet [20, pp. 3–33; 55, pp. 465–538]. The Russian cartridge of 7.62×54R caliber to Mosin rifle, the German cartridge of 7.92×57 caliber to Mauser rifle, the French cartridge of 8×50R caliber to Lebel rifle were the most technically perfect samples in the considered period, as they embodied the most advanced scientific achievements at that time [55, pp. 467–534; 272, pp. 142–144].

With 50th nineteenth digits gained development korotkostvolnoe manual small arms firearms — automatic pistols and revolvers, for called the shots from which have become be applied unitary bullets. Unified models of pistol cartridges at that time did not exist, so the designers pistols were designed for these cartridges yourself. French gunsmith K. Lefoche in 1836 invented a revolver for a spire unitary cartridge of his own design [204]. This cartridge originally had no protruding flange (edges) and was fixed in the chamber stud. The flange of the sleeve it appeared later under the influence of Chuck design L. Flaubert.

In 1860, the English gun designer C. Lancaster, using the ideas of the designs of cartridges K. Lefoche (folder casing, metal pallet) and L. Flaubert (flange), developed a breech-loading hunting rifle under the cartridge of its own design (a prototype of the hunting cartridge used in modern smoothbore hunting weapons) [55, p. 297, 305; 157, p. 137; 218, pp. 134–150].

Belgian gunsmith L. Nagan, using a revolver cartridge and the development of his compatriot G. Piper, designed a revolver, which in 1895 was adopted in the Russian army [171, p. 11].

German design engineer H. borchardt in 1893 and the brothers Federle in 1895 proposed the first successful design of automatic pistols for unitary cartridges of their own design. The modified design of the unitary cartridge of H. borchardt was later used by the German designer G. Luger in the creation of a 9×19 caliber cartridge and an automatic pistol R-08 "Parabellum" [75, p. 23; 172].

Thus, the analysis of scientific literature on the history and improvement of small firearms, ammunition (ammo) to it shows that at the beginning of the XIX century was designed quite perfect samples of small firearms for firing using a unitary cartridge.

In further implemented technical upgrading the as design patron in a whole, so and individual his elements: invention smokeless gunpowder, the creation new species design thimbles and bullets, reducing caliber and raising rate of fire weapons. This trend continued until the end of the XX century. A. A. Blagonravov said: "the history of the development of any branch of engineering gives us countless examples of first, as new advances in technology summarize the huge experience of the previous stages of development, reflect and Refine previous achievements on a new technical basis, second, on the new basis back, seemingly exhausted and obsolete shape and design, in reality, the newly fertilized dialectical process of development of various aspects of technology" [158, p. 3].

Taking into account the above and based on the information given in the works of A. A. Blagonravov, V. E. Markevich, V. G. Fedorov, M. M. Blum, V. N. Dvoryaninov, V. A. Ruchkin and other scientists, it can be concluded that the improvement of hand-held small arms and ammunition used in it from the moment of invention to the end of the XIX century is a continuous progressive process consisting of the following stages:

the invention of firearms, which uses the principle of expanding gases produced by the combustion of a propellant charge;

transition from a muzzle-loading hand-held small-arms firearm to a breech-loading one;

the creation of a unitary cartridge, which led to an increase in the rate of fire of hand-held small firearms;

the invention of smokeless powder that improve the speed of a bullet when fired and thus increase the lethality, range and accuracy of fire, flatness of trajectory;

the use of certain laws of rational layout of the design elements of cartridges(ammunition), parts and mechanisms of hand-held small firearms;

the use of a rifled barrel in hand-held small arms, providing gyroscopic stabilization of the bullet in flight;

development of the optimal shape and design of the projectile element of cartridges (ammunition) for hand-held small arms (creation of bullets with increased destructive power, tracers, incendiary bullets, determination of their optimal aerodynamic shape) in order to obtain additional properties based on the analysis of their practical use.

In the second half of the XX century — the beginning of the XXI century research in the field of military Affairs, wound and final (terminal) ballistics, as well as developments in the field of Aero- and thermodynamics led to the creation of new types of cartridges (ammunition), significantly different from those used previously, in particular a number of cartridges (ammunition) for special types of hand-held firearms-underwater and "silent". Reducing the caliber and weight of the cartridge, the use of the latest scientific and technical developments contributed to the creation of cartridge-free and multi-bullet unitary cartridges. Reactive bullets and cartridges with swept striking elements with increased transverse load and increased striking capacity have been developed [58, p. 27–90; 198; 228].

Currently, scientific research is underway to create cartridges (ammunition) with easily deformable bullets, bullets with a controllable damaging effect and increased penetrating (penetrating) ability. In connection with the humanization of society, the so-called kinetic hand-held small firearms of limited striking ability (traumatic weapons) have become widespread, the creation of which takes into account the principles used in the historically formed design of hand-held small firearms, the design of the cartridge (ammunition) which includes a solid throwing element.

The use of hand-held small arms not only in the military, but also in the criminal environment (when committing crimes) is due to such its main qualities as the defeat of the target at a considerable range and high striking ability. Design improvements as a long-barreled and short-barreled small firearms (the appearance of multiply charged samples), as well as the possibility of concealed carry, respectively, resulted in a transformation of the crime.

On the basis of the analysis of scientific works on the theory of forensic examination and forensic ballistics, the evolution of special knowledge in the field of forensic research of cartridges (ammunition) used for shooting from small arms as a scientific direction in historical retrospect can be represented as a process consisting of the following main stages.

The first phase (XIV — the first half of XIX century) — designing simplest ways research manual rifle firearms. This period of emergence, development and perfection at the beginning of the simplest methods of study of the damaging effect of various types of shells, vystelennyh of small firearms. Thanks to the efforts of primarily military physicians, wound (terminal) ballistics is emerging as a doctrine about the regularities of the formation and morphology of a gunshot wound, the features of the study of injuries caused by the use of small arms firearms. During this period, mainly under the influence of requests of field surgery, traumatology and forensic medicine, wound ballistics arises and develops.

The second stage (the second half-the end of the XIX century) — the formation of the foundations of forensic research of hand-held small arms, ammunition to it, traces of the shot as a result of the use of achievements of medicine, natural and technical Sciences. At this time, at the junction of the border areas of knowledge, mainly ballistics and forensic medicine, begins to actively develop forensic ballistics. This period can be characterized as a stage of creation of bases of judicial ballistics in the form of complex scientific knowledge about manual small arms, unitary cartridges (ammunition), traces of their application used in the process of police inquiry and judicial investigation at exposure of the persons who have committed crimes with its application.

The third stage (the beginning of the XX century — to the present) is the further development of forensic ballistics as a branch of forensic science. Adaptation of the newest achievements of various Sciences to the solution of problems of judicial ballistics is carried out, methodology and techniques of carrying out criminalistic and forensic experiments of manual small arms, cartridges (ammunition) to it, including definition of objective criterion of their striking action are improved. This period can be considered as a stage of development of forensic ballistics as an integral part of forensic Science.

To substantiate the conclusion about the stages of forensic research of cartridges (ammunition) used for shooting from small arms, consider this issue in more detail, including in the aspect of the Genesis and development of scientific ideas about the forensic study of these objects.

From the analysis of literary sources it follows that initially the study of traces of a shot from a small hand firearm was purely medical in nature. The first mention of a gunshot wound, recorded in chronicle sources, dates back to August 2, 1445 (Brunner), according to other sources — 1444; the first mention of a special tool for feeling a bullet in a wound belongs to the surgeon Pfolspeund (Pfolspeund) and refers to 1460 [186, p. 17].

In the first medical study of bullet wounds man in Russia, dated 1644, it was stated: "...Dr. Wendelinus Sibilant, Egan Belov, artman of Graman went to the Embassy courtyard and examined the deceased Prince, his obuwie wounds, and he was probably injured from a harquebus, wound under the right eye and doctor the wound examined, but the bullet was not found, because the wound is deep, but it was known that the hole is in the head" [205, p. 6].

In the literature it is noted that in civilian life, doctors were often involved in the investigation and the court as experts on issues related to gunshot wounds. A typical example is the examination conducted at the suggestion of the St. Petersburg criminal chamber and the Medical Council Ni Pirogov in criminal cases of the death of retired Colonel P. Yakubinsky (1846), the infliction of gunshot wounds to the Austrian subject Ignatius Saltzman (1853), the deliberate murder of a peasant Stepanida Nagibina (1873), etc. [211, p. 6]. N. I. Pirogov noted that the analysis of the impact on the body of "various properties of weapons and especially wounding shells" is the main thing in determining the "properties of wounds, mortality and success of treatment…" [205, p. 193].

A. V. Nake in the book "Forensic Chemistry" (1874) attempted to summarize the empirical material on the study of small arms and traces of its use, highlighting the three stages of forensic ballistic research: a) expert examination; b) research; c) the answer to the question. In addition, he justified the need for the use of technical means during the examination of firearms, as well as the method of determining the prescription of a shot from a hand-held small firearm on the traces of a shot on the barrier and its parts [175, pp. 91–94].

In the work of forensic physician N. N. Shcheglov "Material for Forensic Research of Gunshot Injuries" (1879), the types of hand-held small arms and throwing elements, as well as the processes occurring when fired, are considered. In addition to reflecting the medical aspects of the examination, the author justified the point of view that the expert has no right to solve issues that are beyond his competence. Thus, in relation to the case of the need to identify the alleged weapon of the crime and the wounding projectile extracted from the corpse, it is noted that "such a question, as having no relation to medicine, should be rejected by the doctor and left to the decision of people knowledgeable and experienced in the arms business" [293, p. 55].

The well-known Belarusian legal scholar V. D. Spasovich also drew attention to the importance of taking into account the expert's opinion in the judicial evaluation of evidence: "When the investigation of the fact of a crime raises such questions, the solution of which requires special technical knowledge and experience in science, art, craft, the criminal court, due to its lack of competence, resorts to techniques, people…" [238, p. 104].

In the late XIX — early XX century. there were the first theoretical works on the study of the damaging effect of bullets of small arms firearms on the human body, which belonged to representatives of military and medical science and were based not only on the analysis of wounds received as a result of hostilities, but also on the results of experimental studies. The publication of the military doctor A. S. Tauber stated that "there is a need in peacetime to study the mechanism of action of firearms, to always be ready to deal with their disastrous impact on the human body" [252, p. 1]. This statement is confirmed by the experiments of the famous Russian gunsmith V. G. Fedorov, conducted in 1911–1913 on horses and cadaver material, during which, in particular, such criteria for the damaging ability of bullets of cartridges (ammunition) of hand-held small arms, sufficient to defeat the target, as the value of the kinetic energy of the bullet and the length of the wound channel were established [272, pp. 142–144].

Researchers, mainly in the field of military science, began to deal with the questions of lethal action of bullets of hand small firearms at the end of the XIX century. This was due to two main reasons: the transition to a hand-held small arms with a reduced caliber and the use of two-element shell bullets of a pointed (oval) shape for firing. Thus, N. P. Potocki in his work "Modern hand weapons: their properties, device and use" (1904) noted that in the human body only the defeat of some organs causes more or less rapid death: it is a wound to the heart, brain or spinal cord, large blood vessels, abdominal cavity; the contour of these organs occupies 25 percent of the front surface of the human body. In addition, 15 percent of the body is occupied by organs, the damage of which is accompanied by severe consequences; wounds, accounting for the remaining 60 percent of the body area, more or less light, "... their painfulness may depend on a greater or lesser deformation of the bullet, the characteristics of the nervous organization, the state of excitement of the wounded; it is impossible"; "the destructive effect of modern bullets on living targets can be considered more than sufficient: at all distances at which shooting has sufficient accuracy, bullets can disable people and horses" [55, p. 462].

The author mentions cases of recovery of individuals with through wounds of the skull and chest, as well as the results of the use of firearms by the British army during the Chitral expedition (1895). It was surprising that many Indians and horses wounded during the attack, did not fall immediately, and retained the ability to active actions "only wounds in the head and stomach were fatal, and some wounded with two or three bullet wounds could go about 10–12 miles" [55, p. 462].

The gradual reduction of the caliber of hand-held small arms, the use of cartridges (ammunition) with smokeless powder and bullets of two-element design for firing from it necessitated the scientific substantiation of the criteria for assessing their striking action. Taking into account the results of the combat use of this type of bullets in cartridges (ammunition) of hand-held small arms in England, new types of bullets of two-element design with a cut shell were tested, including bullets with a core protruding from the shell. Due to the fragility of the shell, when such bullets hit not only the hard but also the soft tissues of the human body, they easily deformed, acquiring a mushroom shape, and thus entailed significant damage to organs and wounds.

Experiments related to the study of the lethal effect of bullets with a weakened shell were conducted in the Russian Empire. Shooting was done in both tethered and moving horses at various distances with full and reduced charges. N. P. Potocki noted that "although bullets with weakened shells and produce wounds of large size, it is difficult to heal, due to the jamming of foreign bodies in them, but such lesions do not so increase blood loss and do not so weaken the wounded that it was worth their introduction; on the other hand, such bullets significantly lose in accuracy and action on solid objects" [55, p. 460].

The described observations concerning the use of easily deformable bullets are confirmed by the modern practice of using these bullets during hunting for medium and large game (boar, deer, elk). So, easily deformable bullets can be used for injury to vital structures of the animal body (skull, heart, spine). Only damage to such organs and wounds provides instant "killing" action, and, for example, with penetrating and through wounds of the abdomen, the injured animal does not lose the ability to move and active defense.

In a result conducted in Russia a special Commission in 1911– 1913 devolving experiences on assessing damaging actions Japanese rifle patrons (ammunition) caliber 6.5 mm established, that for guaranteed destruction human or animal (horse) wounding round in moment destruction goal should possess kinetic energy 80–100 J, under this significant differences in action bullets caliber 7.62 mm and 6.5 mm on goals not revealed [270, pp. 104–121]. A. A. Blagonravov, referring to the results of experimental shooting published by V. G. Fedorov, did not offer his own definition of the term "lethal action", limiting himself to pointing out the lack of elaboration of this issue and the variety of factors characterizing this property [21, pp. 18–24].

The point of view expressed by S. S. Girgolav, according to which the human body reacts to a gunshot wound in a variety of ways, seems justified. This author pointed out that this is due to the different reaction of biological wounds to the effect of the wounding projectile, depending on a number of factors: "when the projectile passes through the brain, enclosed in a dense skull, the destruction of wounds is completely different than when the projectile passes through the air-containing lung wounds. In view of this still N. I. Pirogov came to conclusion, that "action on organic tissue case until indefinitely variously" [186, p. 19].

In connection with the reduction of the caliber of cartridges (ammunition) and hand-held small arms to 7–9 mm, as well as taking into account the results of its combat use in the early XX century experts began to note the low efficiency of shell bullets at close range. This property was due to two factors: the oval shape of the bullet, which is characterized by a minimum transfer of kinetic energy of the target at the time of its defeat; the lack of deformation, unlike previously used bullets made entirely of lead. Eliminate these shortcomings became possible thanks to the use of bullets in cartridges (ammunition) with a blunted tip and some increase in their diameter when used in the design of cartridges (ammunition) used for firing pistols and revolvers. This made it possible to provide a sufficient level of kinetic energy transferred to the target as a result of increasing the inhibitory effect of biological wounds at the time of injury. This damaging factor was called stopping action This damaging factor was called *stopping action*.

In the literature, the following characteristics of the considered damaging factor are given "the ability of the bullet to most quickly upset the vital functions of the organism, immediately (here and further highlighted by us. — *E. L.*) depriving the enemy of the opportunity to own their weapons and the ability to further resistance" [89, p. 13]; "the ability of a bullet when hitting a living target instantly upset functions of the body, depriving the enemy the ability to further resistance" [54, pp. 113–114]; "…the ability to immediately incapacitate living targets" [23, p. 21]; it is noted the importance of "...to have a weapon that could instantly *completely paralyze* the enemy, even when hit in such parts of the body, the defeat of which is not an immediate danger to life" [75, p. 25].

It seems that the statements about the obligation of immediate (instantaneous, absolute) immobilization of the target are debatable for the following reasons:

the area of projections of vital organs on the surface of the human body, damage which entails the onset of instant death, as noted above, is relatively small;

the infliction of severe and significant damage in terms of volume without injury to vital organs (multi-comminuted fractures of the bones of the skeleton, complete or partial separation of the limbs, etc.) is not an obstacle to the provision of active resistance;

the nature of the phase of traumatic shock. In the case of traumatic shock (under certain conditions, it can develop as a complication of a gunshot injury) caused by a gunshot wound, the victim in the first (erectile) phase comes motor excitation with the lack of adequate assessment of both his own condition and the environment. This is due to the protective reaction of the body to the injury, resulting in the blood, in addition to hormones such as adrenaline and norepinephrine, receives endorphin, which significantly reduces the reaction to pain [40, pp. 118–124; 206, p. 71].

Along with the data on the effect of bullets of hand-held small arms on the vital organs of man, scientists also studied data on injuries of the limbs (during the great Patriotic war, they accounted for at least 70 percent of injuries associated with damage to the bones of the skeleton) [186, p. 21]. A. V. Smolyannikov gives information that when wounds caused by bullets and shrapnel, which had significant kinetic energy, at close range (shots at point-blank range), the bones were crushed into many small fragments with the complete destruction of the limb and its separation; at the same time, with increasing kinetic energy, the damage zone and intensity increased [187, p. 170]. The work of M. B. Shvyrkov, G. I. Burenkov and V. R. Demenkov contains similar information obtained on the basis of the study of gunshot wounds of servicemen during the Afghan war (1979–1989) [287, pp. 17–26].

In this regard, at present, the development of new types of cartridges (ammunition) at industrial enterprises is carried out, including with the involvement of medical professionals who assess the damaging effect of bullets of cartridges (ammunition) on a person based on the severity of injuries not only of soft tissues, but also injuries of tubular bones, namely, the number of the most severe multi-comminuted fractures and the length of cracks in the bones [58, p. 147].

However, information on injuries resulting from the use of hand-held firearms during hostilities, confirm the conclusion that the concept of “stopping action” in gunshot wounds associated with severe injuries or traumatic separation of even two limbs of the body, is relative [279; 280].

The stated allows to agree with A. A. Blagonravov’s point of view that such striking characteristics of bullets of cartridges (ammunition) of manual small arms as killing and stopping action, have subjective character, do not give in to any objective assessment expressed in quantitative indicators [21, pp.18–20; 195]. A similar position is held by E. I. Stashenko, who points out that the data on the results of the use of hand-held firearms do not always serve as a sufficient scientific justification for the conclusion about the damaging effect of bullets, and therefore can not be taken in the process of forensic activities. The study of such properties in each case is carried out, as a rule, by means of experimental studies, the reproduction of which in the conditions of expert units is difficult or impossible [245].

By the end of the XIX century in Europe began the formation of criminology as an independent science, the development of which was due primarily to the increase in theoretical knowledge in the natural Sciences, the invention of photography, etc. However, it should be noted that during this period, forensic knowledge was fragmented and did not have a systemic nature.

Thus, the founders of Forensic Science G. gross included in his book "Guide to the investigation of crimes" section on the study of hand-held firearms. This section presents information about the types of hand-held firearms, design elements of cartridges (ammunition), types of throwing elements; reveals the features of expert examination of hand-held firearms, traces of a shot, etc. [51, pp. 62–69].

In 1911, by order of the Minister of justice of the Russian Empire, senior legal adviser S. N. Tregubov and a number of other representatives of this Ministry were sent to Switzerland "to familiarize themselves with the recently established and continuing its further development of a curious branch of criminal procedure law-criminal technique" [263, p. 4], which was taught by the doctor of chemistry Professor R. A. Reiss at the special criminal Department of the faculty of law of the University of Lausanne.

S. N. Tregubov in 1915 noted that "only recently in Western Europe the attention of scientists has been drawn to the study of the improvement of investigative production by applying scientific and technical methods to the investigation of crimes and to the formulation of all branches of forensic examination on a strictly scientific basis" [263, p. 8]. Tregubov's book "Scientific Technique of Crime Investigation" (1912), written on the basis of lectures by R. A. Reis, became one of the first forensic textbooks published in Russian. In the work "Fundamentals of Criminal Technology: Scientific and Technical Methods of Investigation of Crimes" (1915) S. N. Tregubov first introduced the term "criminal technology", which later became (with some clarification) the name of one of the sections of Criminology. It sets out recommendations for the study of including hand-held small arms, ammunition (ammunition) to it, the elements of their design, the possibility of identifying a particular instance of hand-held small arms by its traces on bullets and cartridges, as well as describes the method of obtaining experimental samples [211].

In 1912–1914 in St. Petersburg, Moscow, Kiev and Odessa were established parlours of scientific and forensic examination (existed until 1917). After the October revolution on March 1 1919 the Parlour of forensic examination of the Central Investigation Department was created. For carrying out forensic examinations and inspection of places of incidents on the most difficult cases, including those related to the use of small arms, a Scientific and Technical Parlour was formed in the structure of the said institution [177, p. 392].

A significant influence on the process of development and improvement of forensic ballistics had studies of hand-held small arms, ammunition (ammunition) to it, traces of a shot from it, conducted abroad. In the United States, due to the increase in the number of crimes committed with the use of such weapons, full-scale collections of hand-held small arms (both American and European production) began to be created; methods for obtaining comparative samples of bullets and cartridges were improved. The result of this work was the invention in 1925 by F. O. Gravel of the comparative microscope, in the eyepiece of the prismatic nozzle of which it became possible to visually compare two objects of study simultaneously [211].

As for Soviet science, the undoubted merit in the formation of the domestic forensic ballistic examination belongs to the forensic physician and criminalist V. F. Chervakov, chief forensic expert of the people's Commissariat of health of the BSSR and the first organizer of the forensic medical service in the health system of the BSSR. In 1933 V. F. Chervakov headed the Belarusian research Institute of forensic medical examination and criminalistics [85].

In the book "Forensic Ballistics" (1937) V. F. Chervakov for the first time in the domestic forensic literature introduced the term "forensic ballistics", borrowed from the works of foreign authors. At the same time in forensic ballistics these scientists were allocated the following sections: 1) the study of material parts of manual small arms firearms, patrons (ammunition); 2) carrying out identification researches of manual small arms firearms on the traces displayed on bullets and cartridges; 3) the study of gunpowder and other explosives, as well as methods for determining traces of gunpowder and other substances on clothing and other items that are evidence; 4) criminalistic and forensic examination of gunshot wounds [282, p. 5].

In addition, V. F. Chervyakov describes the design and practical application of water bullet catcher for experimental samples, describes in detail the mechanism of action of projectiles; the analysis of factors affecting the striking ability of bullets [282, pp. 88, 132–134].

In the Soviet period, a significant contribution to the study of issues related to the examination of cartridges (ammunition), the identification of hand-held firearms on the traces displayed on the design elements of cartridges (ammunition) to it, made V. S. Akhanov [9], V. F. Gushchin [53], I. A. Dvoryansky [60], B. M. Ermolenko [69], B. M. Komarinets [99, 100], Yu. M. Kubitsky [115], S. D. Kustanovich [119], A. N. Samonchik [240], L. F. Savran [232], E. I. Stashenko [79], E. N. Tikhonov [258], A. I. Ustinov [267], etc.

These scientists formulated the basic principles of the forensic doctrine of cartridges (ammunition) used for shooting from small arms, from the point of view of forensic science, proposed scientifically based classification of these objects, considered the methodology of their expert research. In particular, the criteria for determining the damaging ability of bullets on the basis of empirical data and methods developed by A. I. Ustinov (1968) [267] and L. F. Savran (1979) [232] are used in expert institutions and currently in the study of small arms, ammunition (ammunition) to it.

The problem of determining the minimum level of destructive power of hand-held small arms and ammunition (ammunition) to it by Soviet forensic scientists began to be actively investigated in the 1960s and 1970s. At the same time, we emphasize that the complexity of this problem in relation to forensic science, in particular forensic ballistics, is to determine the lower limit of the biological target's defeatability, and not the level of guaranteed defeat, which is used in military science [269, p. 9]. Appears to be the correct position L. B. Ozeretskovskaya, E. K. Gumanenko, V. V. Boyarintseva who believe that under the criterion of the damaging effect, you should understand the empirical relationship between the parameters of the damaging factor hurting shell, for certain values which, in interaction with the biological goal is achieved given effect defeat [184, p. 241].

Forensic scientists justified the importance of accurately determining the danger boundary of the projectile, which was due to the need to solve diagnostic problems in the framework of expert research of homemade hand-held small arms. In particular, S. D. Kustanovich stated the point of view, according to which an improvised firing device can be classified as a firearm only if it is capable of hitting a projectile. Under the possibility of defeat, the author considered the presence of such a striking action, in which the bullet penetrates into the pine Board to a depth of at least 5 mm when shooting from a distance of 1 m [120].

B. N. Ermolenko was one of the first noted the dependence of the penetrating wound shells with equal speed on their diameter, therefore to define the boundaries of danger, according to the scientist, it is necessary to proceed not only from the magnitude of the kinetic energy of a hurting shell, but his penetrating ability, which can be installed through the joint efforts of criminologists and forensic [67, p. 39–42].

This approach was reflected in the experiment conducted in 1967 by A. I. Ustinov, and in the methodology developed by L. V. Savran on the basis of the results obtained during this experiment to determine the minimum lethal force of standard and atypical firearms and ammunition [232; 267].

In more detail the issues of determining the objective criterion for assessing the damaging ability of the wounding projectile from the point of view of forensic science are set out in section 3.4 of Chapter 3 of this work.

Since the 1990th, the development of theoretical provisions and practical developments in the field of forensic ballistic examination has been most active in the Russian Federation. This trend was due to a number of objective reasons: the growth of organized crime, the presence of large enterprises for the manufacture of firearms, local military conflicts, a significant number of illegal firearms in the population, etc. Problematic issues of production of forensic ballistic examinations of cartridges (ammunition) used for shooting from hand-held firearms are covered in the works of Russian scientists A. G. Egorov [248], A. V. Kokin [95; 98], S. M. Kolotushkin [93], I. V. Latyshov [146] O. V. Miklyaeva

[167, pp. 78–79], V. A. Ruchkin [235], M. A. Sonis [237], A. V. Stalmakhov [248], V. A. Fedorenko [269] etc.

The development of Belarusian forensic ballistics was promoted by scientific developments of such scientists as A.V. Dulov [65], G. N. Mukhin [173], A.V. Lapin [122], V. M. Logvin [156], and practitioners-A. A. Artyushin, A. G. Kunitsky, V. V. Pototsky, V. G. Shavel, etc.

However until recently forensic ballistics lacked a comprehensive scientific approach to the problem under consideration. Aspects of forensic research of cartridges (ammunition) used for shooting from small arms as independent objects of research are devoted only to separate scientific works [202; 31; 229; 237; 258; 303]. It should be noted that most of these works are more of applied importance, they are more or less affected by the issues of methodological support of examinations of cartridges (ammunition) used for shooting from small arms, characterized by a debatable nature.

In addition, the need to improve the efficiency of methodological support for forensic research of these objects is due to the following factors:

incompleteness of the process of systematization and theorization of a significant amount of disparate knowledge accumulated by forensic ballistics, in relation to the issues of forensic research of cartridges (ammunition) used for shooting from small arms firearms;

ambiguous understanding of the terms and their definitions used in the production of forensic ballistic examinations, not only by the staff of expert units, but also by other interested parties due to their inconsistency with the terms and their definitions enshrined in normative legal acts, including technical normative legal acts that regulate issues related to hand-held small arms, ammunition (ammunition) used for shooting. This problem has been addressed in the publications of both domestic [73; 152] and foreign scientists [108; 147; 237];

the emergence of new, previously unknown species patrons (ammunition).

Proceeding from the above, we believe that the further development of special knowledge in the field of forensic research of cartridges (ammunition) used for shooting from small arms, should be carried out by conducting more in-depth scientific research of applied orientation, the introduction of private methods for solving specific expert tasks.

Consolidation in the methods of expert research of such General methodological provisions as terms and their definitions, criteria for attribution of cartridges of small arms to the category of "ammunition" , etc., will provide a stable theoretical basis in terms of forensic research of these objects of forensic ballistic examination.

Thus, we will make the following generalized conclusions:

1. The emergence and improvement of the design manual of small firearms, as well as the reasons for the transition to use for firing him unitary of the rounds (ammunition) identified in the analysis of literature on various branches of knowledge, due to the progressive processes of scientific and technological progress, which are the continuity and evolutionary nature, as well as the specific conditions of combat use in certain historical periods.

2. The transition from weapons, which used muscle power to small firearms, which used energy of powder gases due to the presence of the latter is the new, characteristic-specific properties (large range, striking ability, the ability to automatically reload while shooting, easy in operation, etc.). In further some principles functioning of and elements design manual rifle firearms extended on other species (pneumatic, barrel gas), that evidence suggests continuity approaches to designing weapons.

3. The use of small arms as a weapon of crime, which in turn led to the need to study its properties by persons with special knowledge in the resolution of criminal cases, was the reason for the allocation of forensic ballistics as an independent branch of knowledge. The initial forensic ballistic studies of hand-held firearms were carried out by forensic physicians, since their practical experience allowed to judge the processes caused by a wounding projectile when it hits the human body, which led to the study of these specialists of the device of hand-held firearms, cartridges (ammunition) used in it for shooting, traces of a shot and shooting. Expanding the scope of theoretical knowledge in the study of these objects made it possible to form a clearer idea of the manual small arms, ammunition (ammunition) to it, to develop the classification of these objects in relation to the tasks of forensic science.

4. Special knowledge in the field of forensic research of cartridges (ammunition) used for shooting from small-arms firearms is currently at the stage of systematization and theorization of the results of expert practice, on the basis of which new knowledge is synthesized. Formation of practice of expert research of the specified objects, as a rule,

is limited to the corresponding type (subspecies) of forensic expert research that predetermined development of a considerable number of private techniques of criminalistic research of the cartridges (ammunition) used for firing from manual small arms firearms.

5. The development of special knowledge in the process of forensic research of cartridges (ammunition) used for shooting from small arms, actualizes the need to develop a unified methodological framework, including the creation of a unified conceptual and categorical apparatus, the study of the laws of improving the design of cartridges(ammunition), its individual elements and their impact on the process of forensic research, the establishment of scientifically based criteria for assigning these objects to the category of "ammunition", determining the suitability of the studied objects for shooting. In addition, need a more in-depth study of a number of issues relating to the use of special knowledge for the classification of cartridges of small arms (firearms) to the category of "ammunition", in particular the definition of the subject, object, tasks of their examination, systematization of methods of this type of expert research, development and implementation in practice of new methods of obtaining objective information about the nature of the phenomena inherent in these objects.

Chapter 2
THEORETICAL AND LEGAL SUPPORT OF CRIMINALISTIC RESEARCH OF CARTRIDGES (AMMUNITION) TO MANUAL SMALL ARMS

2.1. Cartridges (ammunition) as objects criminalistic research (concept, essence, classification)

Currently, one of the unresolved problems of assessing the conclusion of forensic ballistic examination is the use in its content of terms and their definitions that do not meet modern scientific ideas about the objects under study. This applies to both legislative acts and normative legal acts regulating the conduct of relevant examinations, in particular the study of cartridges (ammunition) used for shooting from small arms, traces of their use. However, the accuracy and unambiguity of terminology used in forensic ballistic examination of cartridges (ammunition) are important to ensure its uniform understanding and use in both forensic and law enforcement activities.

It is no coincidence that the literature emphasizes that one of the main elements of the concept of the General theory of forensic examination is the doctrine of the means and forms of communicative activity in the production of forensic examinations; the Central part of this element is the language of the expert, the system of expert concepts and terms designating them. The development and improvement of the General theory of forensic examination largely depend on the development and improvement of its conceptual apparatus, in-depth disclosure of the essence of objects, phenomena reflected in each concept [3, p. 103].

R. S. Belkin notes that the introduction of new terms and their definitions into forensic examination as a specific sphere of scientific knowledge is carried out by expanding the existing basis of theoretical provisions and empirical data [36, p. 98].

Analysis of the relevant legal framework of the Republic of Belarus indicates that the Criminal code of the Republic of Belarus (hereinafter-the criminal code) [266] does not contain definitions of the terms “weapon”, “firearm”, “cartridge”, “ammunition”. Judicial practice is focused on a special normative legal act-the Law of the Republic of Belarus of November 13, 2001 No. 61-Z “on weapons” (hereinafter — the law

“On Weapons”) [181]. Paragraph 3 of the resolution of Plenum of the Supreme Court of the Republic of Belarus of April 3, 2008 No. 1 “On Judicial Practice on Cases on Crimes Related to Illegal Actions Against Weapons, Ammunition and Explosives (articles 294–297 of the code)” [192] contains a directed courts to apply in its activities the terms and their definitions contained in article 1 of the Law “On Weapons”. Thus, the relevant gap in the criminal law has been filled by extending the provisions of the said law regulating the administrative and legal regime of legal arms trafficking to the sphere of criminal law regulation.

This approach needs more detailed analysis. It should be borne in mind that the definitions of terms contained In the law “on weapons” are intended only to facilitate the understanding of the content of the provisions of this normative legal act. These definitions, although they reflect some technical characteristics inherent in various types of weapons, ammunition, etc., are not technical, but have a legal nature of origin and application.

In the legal literature, attention is drawn, in particular by Yu. G. Korukhov, to the fact that in the practical activities of law enforcement agencies, due to the imperfection of designs and textual forms of law, certain difficulties arise in the perception of their content. The legal norm can cover any volume of public relations which are amenable to legal regulation. At the same time, such regulation can be effective only if the methods of regulation correspond to the nature and characteristics of public relations. The problem of perception of law is always mediated by its textual form and appears in the classical form as a problem of legal interpretation [108].

With regard to forensic ballistics, M. A. Sonis notes that the lack of uniformity in the definition of the concepts of “cartridge” and” ammunition” in various fields of knowledge is due to the many approaches to which this scientist refers to the following: the use of the forensic concept of cartridges (ammunition); use of the terms and their definitions contained in legislative and other regulatory legal acts; use of the terms given in the state standards and technical conditions concerning production, storage and use of the specified objects [237].

According to M. A. Sonis, the existence of a problem in law, which can be defined as the regulation of public relations, can not serve as a basis for changing the existing existing provisions, concepts used in various fields of society: technology, military science, etc. [237].

In our opinion, the objective essence of physical phenomena and processes cannot be expressed by a legal definition only using legal approaches, otherwise such a definition will inevitably have a limited character. Natural-scientific regularities exist regardless of society and relations within it. Prescriptions of norms of the law reflecting in the textual form technical, physical and other signs of the phenomena of the nature, should identically reflect their essence and be perceived by the law enforcement agent according to their actual sense in order to avoid double understanding and discrepancies.

These defects of legal regulation complicate the possibility of qualitative assessment of the content of the expert's opinion, and hence the proper assessment of the degree of its reliability, since it is the correspondence of terms and their definitions to the current level of scientific knowledge that allows you to select a particular object of forensic ballistic research from a set of objects similar to it in certain properties and qualities [225; 226].

Expert practice has formed the following approach to the solution of the problem under consideration: when conducting forensic ballistic examinations of cartridges (ammunition) used for shooting from small arms, the terms and their definitions used in the process of its industrial standardization should be applied. This requirement is expressly provided in the relevant methods of research of objects of such examinations [163; 166].

The specified requirement is directed on simplification of perception and an assessment by authorized subjects of proof and other persons of such difficult source of proofs, as the conclusion of judicial-ballistic examination. The use of different approaches to the definition of the terms used in it and their definitions both at the theoretical level (in criminology and other Sciences) and in normative legal acts, state standards and other documents leads to ambiguity of opinions arising during forensic ballistic examination, regarding the attribution of small arms cartridges to the category of ammunition.

Until recently, the theory of forensic examination was dominated by the view that, in relation to the conduct of forensic examination, special knowledge is that which is outside the framework of legal provisions, well-known generalizations arising from life experience [78; 214].

However, now many scientists and practitioners this position is questioned. Thus, A. S. Podshibyakin believes that at the present stage of development of law, judicial experts not only can, but also must take into account, for example, the provisions of national and international legislation and take them as a basis for solving their tasks. In this regard, in relation to Russian practice, the author points out that forensic experts should be guided by both traditional provisions of criminology (in particular, relating to the classification and characteristics of weapons) and the content of the laws of the Russian Federation and international law [208]. I. V. Latyshov notes that the starting point in the field of expert research of small arms, ammunition, traces of their use should be considered a set of terms enshrined in the normative legal acts regulating the circulation of weapons, industry terms and their definitions of forensic ballistics, Military and Technical Sciences [147, p. 8–13].

In the forensic literature as an example of application in forensic activity of the legal knowledge reflected in provisions of normative legal acts, the decision of classification tasks at carrying out forensic ballistic examinations of manual small arms, cartridges (ammunition) used for firing from it, etc.

Thus, it is implied that in the process of conducting these examinations, the expert identifies the necessary set of features of the objects under study, which correlate with the features enshrined in the relevant legal definitions contained in the texts of normative legal acts establishing the state-legal regime of circulation of small arms and ammunition (ammunition) to it [91].

The close connection of forensic ballistic examination with the state legal regulation of the turnover of cartridges (ammunition) used for shooting from small arms is that the conclusion of forensic ballistic examination is the only source of information about technical characteristics (features), information about which is formally unavailable for perception by other subjects of law enforcement activity in the process of resolving a criminal case on the merits.

Proceeding from the theoretical position on the unity of forensic technology and the principle of legality, the technical competence of the employee of the body of inquiry, the investigator, the Prosecutor can not be formally limited; in this regard, such persons are subject to the only requirement: the material evidence, subjected to research by scientific and technical methods, should not be destroyed or changed; in each concrete period there is a certain objective boundary of possibilities of use of scientific and technical methods and means of research of material proofs by the employee of body of inquiry, the investigator, the Prosecutor and the expert [212, pp. 267–269].

This conclusion is based on the fact that the cartridges (ammunition) used for shooting from small arms are specific objects of the material world, the study of which requires special knowledge and the necessary technical means. Some scientists note that the study in the form of expertise involves obtaining such new factual data that were not known to the law enforcement officer and that can not be obtained in other ways, in connection with which the purpose of a special study of forensic objects is not only to ascertain the new facts of objective reality established by the expert, but also in their special, professional assessment [91].

However, as already mentioned, based on the General provisions of the theory of forensic examination, the expert bases his conclusions solely on existing scientific ideas, provisions of technical regulations and methods of forensic research of objects of forensic ballistic examination. On the basis of special knowledge in the relevant field of science, technology, art or craft when conducting research and solving the expert task, the expert establishes and evaluates the compliance of the necessary and sufficient set of signs of the object under study with the complex of signs inherent in hand-held small arms, cartridges (ammunition) used for firing from it, and then sets them out in the form of conclusions. In the research part of the expert's conclusion, other essential features of the object under study are also indicated, which allow to qualitatively determine its properties. In this regard, it is advisable to support the point of view of T. V. Averyanova, according to which in such cases there is an establishment of the technical and not the legal side of the phenomenon under study, since the conclusion obtained in the course of the examination does not prejudge the General conclusion about the guilt of the person [3, pp. 189–190].

It should be emphasized that the approach to the definition of the concept of "cartridge" in criminology, military and technical Sciences after the transition in the early XX century. to the use of hand firearms unitary cartridge to date has not undergone any significant changes. In encyclopedic and special literature contain the next definitions patron: "compound in one thing whole bullets, gunpowder weapons and the capsule " [39, p. 319]; "a firearm munition in which a bullet, a propellant and a means of ignition are combined into one whole by a sleeve"

[40, p. 279]; “a small arms munition, which is an Assembly unit consisting in General of a propellant element, a propellant charge, an igniter capsule and a sleeve” [190, p. 35] etc.

Similar definitions of a unitary cartridge provides Russian researchers A. G. Egorov, A. V. Stalmakov, A. M. Sumaroka and A. G. Sukharev, “Chuck, where by the casings are connected together bullet, powder charge and primer-igniter” [248, p. 43], I. V. Gorbachev and A. V. Mileva, “Chuck, all elements of which are United by the sleeve” [112, p. 42; 167, pp. 78–79], as well as Belarusian scientist A. V. Dulov: “a device in which the charge the bullet and the primer-igniter cartridge combined into a single entity” [65, p. 211], etc. Reflected in the theoretical sources of the General characteristics of the cartridge as a constituent element of the weapons complex and the object of forensic research, the essence of which is to combine as a single device propellant charge, propellant element and primer-igniter (initiation device) through the sleeve, reproduced in the legislation. So, in paragraph 13 of part 1 of article 1 of The law “On Arms” the following definition is fixed “the cartridge-ammunition in which the thrown element, the throwing charge and means of initiation are United in one whole by means of a sleeve” [181].

The word “munition” in the definition of “cartridge”, used in the military and technical Sciences, appeared after the Second world war as a result of theoretical developments in the field of weapons, the effectiveness of which is constantly improved. The result of theoretical research was the introduction of a new term “complex weapons”, denoting a set of samples of military equipment, functionally related and used to solve combat problems. At the same time, attention is drawn to the fact that the mandatory element of the weapons complex is the weapon together with the means of destruction (ammunition), directly intended to defeat the target [241, pp. 19–20].

In legal science, the term “ammunition” is associated with its introduction into the criminal code of the RSFSR in 1960, since the criminal codes of the RSFSR in 1922 (article 220) and 1926 (article 182) it was exclusively about firearms. Resolution VTSIK and SNK RSFSR from 20 March 1933 “About climate article 182 Criminal Code” in quoted article was introduced addition, in a result what part of the first formulated the next way:” the Fabrication, storage, purchase and sale explosives substances or projectiles, and would still firearms (except hunting smoothbore) weapons without proper resolution…”. Since the term "shells" did not reflect the essence of the term and allowed ambiguous understanding, the Criminal Code of the RSFSR in 1960 and the Union republics introduced the term" ammunition" [6, p. 20].

In the Law "On Weapons" and the state standard of the USSR 28653-90 "Small Arms. Terms and Definitions" (hereinafter-GOST) [190, p. 35] contains terms and their definitions relating to the objects of factory production: manual small arms and ammunition manufactured by industrial enterprises. Issues relating to ammunition (ammo) improvised, and improvised firearms that are the subject of forensic investigation, the Law "On Weapons" and the GOST is not regulated, because such objects, though made in the likeness of industrial designs (fully or partially) or their components (parts), do not meet the technical requirements of industrial production.

In the first part of article 1 Of the law "On Weapons" the legislator establishes legal terms and their definitions used in law enforcement practice. Such norms-definitions as a General rule are designed to facilitate the understanding of the essence of the provisions of the normative legal act by the subjects of law enforcement and perform "heuristic, guiding and orienting functions in the mechanism of legal regulation of the relevant sphere of legal relations" [254, p. 406]. As a result of understanding the meaning of the term the law enforcement officer is able to correctly interpret the provisions of the normative legal act containing it. This facilitates the perception by this subject of the meaning of the norms, the wording of which includes complex specialized, including some technical terms included in the legal construction of the provisions of the relevant regulatory legal act (in this case — The law "On Weapons"), characterizing such objects of the material world as hand-held small arms, ammunition (ammunition) used for firing from it.

The use of special terminology borrowed from technical and military literature (manuals, standards, specifications, etc.), is only auxiliaryAt the same time, the text of the expert's opinion may contain references to the provisions of technical normative legal acts, which will facilitate the assessment of the reliability of the substantive part of the forensic ballistic examination conclusion and thus have a positive impact on law enforcement practice. A similar position is held by Russian scientists, who believe that the terms used in forensic ballistics and their definitions require unification, since only in this case it is possible to achieve unambiguity of terminology [95, pp. 36–37].

In the legislation of the Republic of Belarus the problem of unification of terms and their definitions established in article 1 Of the law "On Weapons" with the terms and their definitions contained in the methods of research of various types of weapons, in technical normative legal acts defining mandatory *technical* requirements for weapons, the processes of its development, production, operation (use), storage, transportation, sale and disposal remains unsolved.

Certain terms and their definitions provided for by the provisions Of the law "On Weapons" are characterized by uncertainty, and therefore need to be adjusted.

The analysis of the terms and their definitions enshrined In the law "On Weapons" shows that article 1 of this law is of a regulatory and technical nature, since the definitions of terms contained in it are based on the technical characteristics inherent in these objects. In order to facilitate the law enforcement perception of the provisions of this law, the legislator is forced to use technical features in it. At the same time, it should be emphasized that the Law "On Weapons", which establishes the legal regime of turnover of hand-held firearms, cartridges (ammunition) used for firing from it, does not define the technical features of the device of these objects, but regulates public relations related to the right of possession, use and disposal by authorized entities of certain types of hand-held firearms, cartridges (ammunition) to it. As already emphasized, only an expert, based on the relevant knowledge in forensic ballistics and information from related Sciences, has the right to establish the technical characteristics and design features of such specific objects of research as hand-held firearms, cartridges (ammunition) used for firing from it, in turn, the exclusive prerogative of the law enforcement officer is to assess the content of the conclusions obtained in the process of forensic ballistic examination.

The presence of legal uncertainty is characteristic, in particular, for part two of article 6 and part two of article 7 Of the law "On Weapons", the norms of which prohibit the use in service and civilian weapons cartridges (ammunition) "with cores of solid materials" [181], but the hardness criteria for the materials of the cores of bullets in this law are not established, which may lead to different understanding and different application of these norms in practice.

It should be noted that some terms and their definitions contained in article 1 of The law "On Weapons" are not fully consistent with the provisions of technical regulations governing issues related to the technical regulation and standardization of small arms, ammunition (ammunition) used in it for shooting, as well as insufficiently take into account modern scientific ideas about these objects of expert research. In particular, the definition of the term "ammunition" given in the said law fully reproduces the definition enshrined in the relevant technical normative legal act intended for use in military science, military technology and military production. This definition does not fully reflect the properties of objects for the regulation of the turnover of Which the law "On Weapons" is intended, since, for example, cartridges (ammunition) for smoothbore hunting firearms, homemade, reloaded cartridges are not products of military production [108].

In addition to the differences in terms and their definitions used in the military, technical, forensic fields of knowledge, this discrepancy is due to the fact that in the process of knowledge, a person distinguishes in the surrounding objects the General, essential, specific, natural, distracting from the accidental and secondary, resorting to simplifications and schematization. From the philosophical point of view, such simplified, schematic objects are introduced by means of definitions, making it unnecessary in each case to reduce the complex (complex concepts and objects) to the elementary (to the concepts and objects of the original basis of the theory). At the same time, the definitions are limited, that is, do not reflect the entire content of the studied subject (phenomenon), which is described by the relevant branch of science [277, p. 152].

With regard to the formulation of definitions of terms used in the production of forensic ballistic examinations, E. N. Tikhonov considers it necessary to be guided by a number of principles: 1) the terms used and their definitions must comply with the laws of formal logic; 2) the basic (initial) should be the concepts developed in military-technical and other Sciences (at the same time such terms should be rethought and, in accordance with the objectives of forensic science, make appropriate changes and clarifications); 3) in the course of the formation of the conceptual apparatus used in the production of forensic ballistic examinations, special attention is required to the concepts contained in criminal law [259, pp. 16–17]. A similar opinion is held by T. V. Averyanova, who believes that, along with the knowledge of the General scientific nature of the terms, it is no less important to concretize the concepts that are designated by these terms, especially in the case when the term borrowed by one area of knowledge (in particular, forensic expertise) from another, has a different meaning [3, p. 109].

Special knowledge used in the production of forensic ballistic examinations of cartridges (ammunition), based on the laws of the development of scientific ideas and technical improvement of these objects of study. Unification of terms and their definitions used during forensic ballistic examination of cartridges (ammunition) used for shooting from small arms, specification of provisions of normative legal acts contribute to ensuring their unambiguous perception and uniform application in law enforcement practice, in particular, allow to increase the reliability of the expert's opinion, to ensure the possibility of its evaluation by persons conducting an inquiry, investigators, prosecutors and judges.

This circumstance is important for the sphere of expert research, since the content of the expert's opinion must meet, among other things, the requirements of scientific validity and credibility, accuracy and scientific determinism. If an expert violates these requirements, such a study cannot be a priori recognized as qualitative, objective and reliable [226]. In addition, the unification of terms and their definitions is one of the fundamental trends in the development of the language of science: the number of terms denoting the same object is reduced; several existing terms are replaced by one new term, which does not appear alongside the old ones, but instead of them [301, p. 118].

It should be noted that norm-setting activities should be observed flowing from the Constitution of the Republic of Belarus of the rule of law (article 7) [105] the principle of legal certainty that suggests the clarity, accuracy, consistency, logical coherence of provisions of normative legal acts. This pre-empts their ambiguous understanding and, consequently, improper application, creates conditions for uniformity and predictability of law enforcement practice [191].

As mentioned earlier, the conceptual and categorical apparatus, reflecting the technical characteristics and requirements for cartridges (ammunition) of industrial manufacture, mandatory for the production and operation of these facilities, is not contained in The law "On Weapons", but in the relevant technical regulations. According to the Law of the Republic of Belarus of January 5, 2004 "On Technical Regulation and Standardization", the norms of this law and technical regulations regulate relations (note that this does not indicate the public nature of relations) arising in the development, approval and application of technical requirements for products, processes of its development, production, operation (use), storage, transportation, sale and disposal [193].

In practice forensic-ballistic research patrons (ammunition) should be guided by term “munition”, developed forensic science, because aside from patrons (ammunition) factory assemble this the notion of should encompass also similar on device and principle actions fully homemade and peresnaryazhennye patrons (ammunition).

Currently, in the literature on forensic ballistics and forensic medicine, the most commonly used definition is: “ammunition is a multicomponent in its design, disposable items designed to hit a target using explosives as a result of a firearm shot or explosion” [211, p. 35; 248, p. 42]. In accordance with the fourth paragraph of section 1 Methods of forensic investigation of firearms traumatic ammunition related devices and objects designed specifically for hitting the target, performing tasks, contributing to its defeat and containing explosive, pyrotechnic or propellant, or a combination [161].

Thus, in the given provision the definition of the term “ammunition” fixed in article 1 of The law “On Weapons” is literally reproduced”. The use of this definition in the text of the mentioned methodology is not fully justified, since it does not reflect the concept in question from the point of view of forensic ballistics. In this regard, in relation to the forensic ballistic examination of cartridges (ammunition) used for firing small arms, it is advisable to develop a narrower definition of the term “ammunition” in relation to these types of objects of expert research.

In paragraph 26 of section 3 of the previously valid in the Republic of Belarus Methods of forensic examination of cartridges of small arms, their serviceability and suitability for use for the intended purpose (hereinafter — the method of forensic examination of cartridges) fixed the following definition of the term in question: ammunition (from the point of view of forensic ballistics) is a multicomponent in its design, disposable items designed for mechanical destruction of the target at a distance by a projectile thrown with the energy of powder gases or other explosive substance as a result of a shot from a firearm [163].

In Russian scientific literature (particularly in the work of D. A. Storms) ammunition used for shooting from manual small firearms, defined as “disposable, multi-piece item is designed for target projectile as the result of a shot in the corresponding sample handguns” [31, p. 66].

These definitions also do not fully meet the goals and objectives of forensic ballistic examination. As noted by M. A. Sonis, analysis of the definitions of "ammunition" and "Chuck" suggests that the concept of "ammunition" in forensic science reflect the purpose of items, in contrast to the term "cartridge" which defines only the product design, in connection with the issue of ammunition should be used as knowledge in engineering and military science to uncover the nature of these concepts [237].

Currently, in military and forensic science, a sample of hand-held small arms with a cartridge used for firing from it is considered as an integral complex "weapon-cartridge", the elements of which interact with each other in the process of functioning. The effectiveness of this complex in the process defeats the purpose almost entirely determined by the cartridge [32, p. 7]. Thus, in the specified context of the "weapon — cartridge" system, we are talking about a sample of firearms manufactured for a specific sample of the cartridge. In turn, the cartridge as an integral part of the "munition — weapon — target" system is considered as a munition, that is, a device designed to defeat the target as a result of firing. From the point of view of forensic ballistic examination, the term "munition" in relation to the cartridge used to fire small arms, is understood in the context of the use of a projectile element (bullets, buckshot, shot) on the target and causing it life-threatening injuries. This explains the difference in approaches to understanding the essence of the term in forensic, military and technical Sciences.

In technical science, a cartridge (ammunition) is understood as a device, i.e. a set of elements representing a single design (technical system) [66, p. 2]. The main functional purpose of this device is to ensure the production of a shot from a hand-held small-arms fire-strelnogo weapons and defeat the target.

Thus, due to the presence of a minimum sufficient set of design elements in the device of the cartridge (ammunition), the functioning of the technical complex "ammunition — weapon" as a single technical system is ensured. The use of the elements of this system in a disjointed form in order to achieve the expected results from the standpoint of existing scientific concepts is impossible, since a technical system is a set of interrelated elements combined into one whole to achieve some goal determined by its purpose [5, p. 9].

This is confirmed by the following example. The German firm Cuno Melcher in 1996 began production of pneumatic revolvers for firing from which the pneumatic cartridge Air-Cartidge is used, externally close in form and dimensional characteristics to a revolver cartridge of caliber 357 (figure 2.1.1).

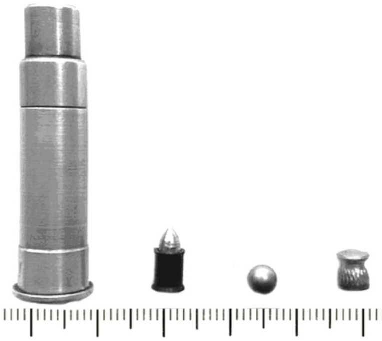


Figure 2.1.1 — **General view of the cartridge "Air Cartridge" and the throwing elements used in it** [113, pp. 11–18]

Expert practice shows that the design features of this cartridge can be used to turn it into ammunition for hand-held small arms (figure 2.1.2).

Figure 2.1.2 — **General view of the homemade cartridge (left), the cartridge "Air Cartridge" (right)** [113, pp. 11–18]

In the center of the bottom of the sleeve of this cartridge is the stem of the nipple, closing the hole in the spout of the sleeve and preventing the exit of compressed air from it through the spout (figure 2.1.3).

Figure 2.1.3 — **General view of the structural elements of the cartridge “Air Cartridge” after dismantling** [113, pp. 11–18]

When exposed to the cartridge rod nipple opens, resulting in a bullet under the influence of excess pressure of compressed air is ejected from the cartridge.

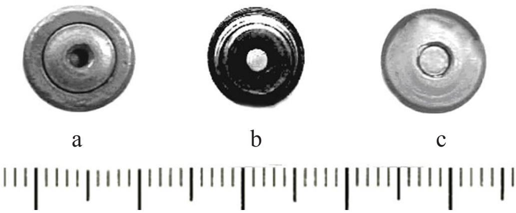


Figure 2.1.4 — **General view of the bottom of the holder “Air Cartridge” (a, b) and improvised cartridge (c) represented in the study** [113, pp. 11–18]

In the study received by the State forensic center of the Ministry of internal Affairs of the Republic of Belarus pneumatic revolver “ME 38 Magnum-4,5 D” and five rounds of ammunition, it was found that one of the five cartridges were used cartridge parts “Air Cartridge”, ie sleeve with nipple and cap made of copper alloy (brass). In addition to these parts, a self-made metal cylinder with a length of 15.9 mm, a diameter of 8 mm, filled with a powder charge, was placed in the casing of the sleeve, a primer-igniter of the Central battle was mounted in one of the end sides of the cylinder (figure 2.1.4 c). Steel pointed bullets were used as projectiles. As an intermediate part for ignition of the initiating composition of the primer-igniter and the powder charge, the nipple rod of the sleeve itself served (figure 2.1.4 a, b).

In the four other cartridges presented for the study, only their shaped and dimensional characteristics fully corresponded to the characteristics of the cartridge "Air-Cartridge", and the sleeves themselves were completely made of brass. In the bottom of these sleeves are mounted caps-igniters of the Central battle (figure 2.1.4 c), and the propellant charge is placed directly into the housing of the sleeve and closed wad, which is placed on the bullet.

During the experimental firing to determine ballistic and destructive properties of pneumatic gun "ME 38 Magnum-4,5 D" using data cartridges was an expert experiment in which the measured initial speed of methane elements using hardware-software complex "Regula". According to the results of the experimental study, it was found that the initial velocity of the projectiles ranged from 255 m/s to 374 m/s. At the same time, the specific kinetic energy of the projectile elements of the cartridges repeatedly exceeded the lower limit of human damage (0.5 J / mm^2) [113, pp. 11–18].

According to the results of the study the expert formulated the following conclusions:

the cartridges presented for the study are ammunition;

the revolver under study in conjunction with these cartridges is a manual small arms firearm [113, pp. 11–18].

The analysis of process of improvement of cartridges (ammunition) used for firing from manual small arms, carried out in Chapter 1, testifies that emergence of new properties of these objects was caused including change of characteristics of the struck purpose (in more detail will be considered in section 3.4 of work). Properties of the system "munition-weapon", currently taken into account in military and technical science in the design of new types of cartridges (ammunition), in our opinion, should also be considered from the point of view of the affected target in relation to the tasks of forensic ballistic research. As already noted, the cartridge (ammunition) and a sample of hand-held small arms, for firing from which it is used, is an indivisible technical complex "ammunition-weapon", characterized by a set of certain ballistic properties in relation to specific conditions of use when hitting a certain target. Thus, in the specified system it is necessary to include also such element as the purpose as its properties define parameters of a technical complex "ammunition — weapon".

In order to analyze the properties of the munition — weapon system, it seems justified to consider it in more detail on the basis of the General characteristics of complex systems.

Complex systems are characterized by basic properties, respectively, requiring a systematic approach to the study. Such properties include: *integrity* — the system is considered as a single object consisting of interacting elements, unequal in essence, but compatible; *connectivity* — the presence of stable connections between the elements of the system and (or) their properties that determine its integrative properties; *organization* — the presence of a certain structural and functional organization that determines the possibility of creating a system; *integrativity* — the presence of qualities inherent in the system as a whole, but not peculiar to any of its elements individually (although the properties of the system depend on the properties of the elements, but are not determined by them in full) [5, p. 11].

From the point of view of forensic ballistics, the design of a cartridge (munition) generally consists of a projectile element (bullet, buckshot, shot), a propellant charge, an initiation device (capsule), combined by means of a sleeve [31, p. 66; 163, p. 35; 190]. The absence of at least one element in the design under consideration does not allow the cartridge to be classified as a "munition" in its forensic meaning. Each of the elements of the cartridge (ammunition) performs one or more functions. In particular, the *throwing element* is designed to directly hit the target as a result of firing from a hand-held small-arms firearm by giving it a certain speed of translational rectilinear motion as a result of the shot; *the initiation device* is designed to ignite the propellant charge of the cartridge (ammunition); *propellant charge* as a result of chemical transformation creates in the chamber of the sleeve and the barrel channel excess gas pressure, providing the process of firing; *the sleeve* combines all elements of the cartridge (ammunition) into a single device, provides obturation of the barrel bore and locking unit, protects the propellant charge and the initiation device from external influences [54, p. 188].

This allows you to determine the set of properties possessed by the cartridge (ammunition) from the point of view of forensic science. Such properties of the cartridge (ammunition) include the following:

it is a device structurally provided and functionally designed to engage a target at a distance as a result of firing from a hand-held small-arms firearm;

the design of the munition is a set of interrelated elements that ensure the functioning of the complex "munition-weapon" and implement its intended purpose — the location of the target at a distance;

defeat goal is undertaken moving in space single (bullet) or multiple (shot, buckshot) metaemym element of design patron (of ammunition);

the action of the thrown element on the target is single and non-renewable;

movement of the thrown element is provided by creation of excess pressure of gases in the closed volume of the cartridge case (ammunition) and (or) the channel of a trunk of manual small arms firearms;

overpressure of gases in the process of the shot is the result of irreversible chemical transformations in the combustion or detonation of the substances (powder, solid rocket fuel, liquid fuel and oxidizer, etc.), able in a short period of time to form the amount of gases to give the methane element required for its movement and the target speed;

the movement of the throwing element is oriented in the direction of the target, which is due to the historically developed design of hand-held small arms (the presence of the barrel or part of the shell casing);

the main striking property of the projectile element of the cartridge (ammunition) is the transfer of the target of the required amount of kinetic energy at the time of defeat.

Based on the above, the munition of hand-held small arms is a single-action device, structurally provided and functionally designed to hit the target with a throwing element as a result of firing [140; 143].

The proposed definition reflects the essence of the term based on the technical nature of the occurrence, as well as the specifics of forensic ballistic research of the objects in question. Application of this definition in practice at production of criminalistic research of the cartridges (ammunition) used for firing from manual small arms, will allow to provide the uniform methodical approach, to eliminate terminological limitation, to carry out differentiation of the similar terms used in adjacent areas of scientific knowledge, and thereby to increase quality, reliability and validity of expert conclusions.

The given definition, in our opinion, reflects sufficient for the solution of problems of forensic ballistic examination set of the following defining essence of the cartridge (ammunition) of manual small arms firearms signs:

functional (target) purpose — the purpose of the cartridge design to defeat the target as a result of firing from the corresponding sample of hand-held small arms;

structural security — the presence in the structure of the minimum required number of elements required for its operation;

complexity — the Union of different purpose of structural elements in a single device;

single use — the possibility of a single use for the intended purpose;

defeat of the purpose as a result of firing by the thrown element with sufficient level of striking properties-possibility of causing the penetrating injuries dangerous to life and health of the person.

The analysis of practical activity of expert divisions testifies that now as objects of forensic ballistic examination the set of types of cartridges (ammunition) differing from each other in a way of production, features of a design, technical characteristics and ballistic parameters acts. In connection with the progressive and dynamic development of science and technology, new types of cartridges (ammunition) have been developed, information about which is not even available in the reference literature. This makes it necessary to systematize the available information about cartridges (ammunition), their elements, since the question of attribution of cartridges to the category of ammunition is associated not only with their concept, but also with the classification and systematization of knowledge and their application.

In forensic Science, system-structural and classification approaches are widely used. This is due, on the one hand, to the need for a permanent organization of science itself as an object in continuous development in order to create a broad scientific potential, and on the other hand, the need for effective, scientifically based application of this potential in practice [30].

Classification of objects of research in the theory of forensic examination is an essential condition for the effective solution of the problems of expert research. Only in the presence of the developed classification system, the most complete and comprehensive study of objects based on the choice of the optimal method of their study is possible [95, p. 44]. Based on dialectical principles, classifications transfer the focus to the disclosure of internal, natural connections between groups of classified objects, reflect the moment of their origin and change, logical connections and relationships between them, while they must have maximum flexibility and exclude artificiality, arbitrariness and subjectivism.

At the same time, E. N. Tikhonov emphasizes that a properly formed classification should be accessible for use, visual, due to the needs of practice, allow the use of additional grounds if necessary [259, pp. 16–17].

As in the theoretical sources devoted to the forensic ballistic study of cartridges (ammunition) used for shooting from small arms, and in the methods of expert research of these objects there is no clear system of established grounds for classification, while from the point of view of forensic science they are essential, in particular in determining the source of evidentiary information. In the process of investigation and disclosure of the crime tools and means of its Commission are considered, as a rule, in connection with the establishment of the method of Commission of the crime, the identity of the offender, but at a certain stage they may have an independent value, for example, in determining the common origin, search tools and subsequent identification to determine [71, p. 158].

Following the rules of formal logic, the basis of classification should occupy a strictly defined place in it and should be designed for long-term use without any significant changes. Thus, the main task of classification is to systematize the field of knowledge to facilitate orientation in both scientific and practical activities. However, any classification is the result of the application of certain assumptions that define the boundaries of certain types of classified objects [275, p. 177].

Based on the above, from the point of view of materialistic dialectics, it seems reasonable to consider the currently existing classifications of cartridges (ammunition) used in criminology, forensic ballistics and forensic medicine.

Thus, A. G. Egorov, A. V. Stalmakhov, A. M. Sumarokov and A. G. Sukharev developed a classification of cartridges (ammunition) for hand-held firearms as objects of forensic research on the following grounds:

1) in structure — unitary, non-unitary, caseless;

2) at the location of the initiating composition — cartridges Central combat, the cartridges ring of ignition, cartridges side ignition (conifers);

3) for the intended purpose-combat (army, police), civilian (hunting, sports, gas), simulation (idle, noise, training), verification (to check the trunks, locking device, ballistic properties of weapons);

4) by caliber-small caliber (less than 6.5 mm), normal caliber (6.5–9 mm), large caliber (more than 9 mm);

5) by type of weapon used — rifle, intermediate pistol, revolver;

6) according to the method of manufacture-industrial, homemade;

7) in relation to the weapon in which they are used, — regular, cartridges-substitutes, non-standard [248, pp. 43–45].

A similar classification with minor differences is introduced in the works of V. L. Popov, V. G. Shigeev and L. E. Kuznetsov [211, pp. 35–36], V. A. Buri [31, pp. 46–49] and S. V. Yatsenko [303, pp. 53–54]. At the same time, the authors develop the classification approach set forth in the works of such founders of domestic forensic ballistics as V. F. Chervakov [281, pp. 54–64], B. M. Komarinets [102, pp. 59–97] and E. N. Tikhonov [253, pp. 11–14].

S. V. Yatsenko cartridges (ammunition) to manual small arms in addition classifies on two bases:

1) according to the mechanism of the damaging action-kinetic action, irritating action (equipped with substances-irritants), light-sound action;

2) by efficiency of mechanical striking action-cartridges-ammunition, cartridges of limited striking action (the value of their specific kinetic energy is less than 0.5 J/mm^2) [303, pp. 55–56].

I. V. Gorbachev and O. V. Miklyaeva cartridges (ammunition) are classified similarly on such grounds as design and method of production. In addition, depending on the method of initiation of the propellant charge, these objects are divided by the authors into cartridges (ammunition): with shock ignition (spike cartridges, ring ignition cartridges, Central battle cartridges), with electric ignition. Some difference is also proposed by the authors of the classification of cartridges (ammunition) using such grounds as functional purpose, in connection with which they are allocated military (primary and auxiliary), service, civil (hunting and self-defense weapons) cartridges (ammunition) [112, pp. 40–54].

In particular, in The methodology of forensic research of cartridges, cartridges were classified only by their design, on the basis of which its authors identified unitary loading cartridges, non-unitary cartridges and cartridge-free cartridges [163].

The analysis of the given classifications of cartridges (ammunition) as objects of criminalistic research allows to draw a conclusion that in them the approaches developed by judicial ballistics in the course of its formation and development are used. At the same time, the attribution of cartridges (ammunition) to some groups is not fully justified due to the lack of a clear understanding of the technical device of these objects of expert research.

In the above scientific classifications, methods of forensic research of cartridges (section "Concept and classification of cartridges") are allocated such types of cartridges as non-unitary. In our opinion, this position is controversial on the following grounds:

1) the term "not unitary patron" in military science and technical literature on designing patrons is missing, under him is understood ambivalent patron separate loading, used in XVI — the eighteenth centuries for called the shots from dulnozaryadnogo manual rifle firearms. The elements of this cartridge United by means of a paper sleeve are not a device from a technical point of view, but represent a set of objects United in a design for protection of a propellant charge from external influences and increase in speed of loading. Currently this kind of patron in practice expert research virtually not meets in view transition to use of for called the shots from manual rifle firearms unitary patrons. Thus, the allocation of it as a separate type of ammunition is debatable and hardly justified, since in accordance with the provisions of the methodology of forensic research of cartridges, such a cartridge is not ammunition;

2) the division of cartridges for the intended purpose (army, police, civil, simulation, testing) is also not fully justified, since some of the terms given in the classification, in fact, replace the technical terms and their definitions enshrined in technical regulations, which more fully characterize the objects under study. This does not contribute to achieving the unity of scientific terms and unification of the conceptual and categorical apparatus of forensic ballistic examination, which in practice can lead to ambiguous perception and different applications, since from the point of view of technical science, for example, there are no clear criteria for distinguishing between "army" and "police" cartridges (ammunition) for hand-held small arms.

Thus, the Armed Forces of the Republic of Belarus, the Ministry of internal Affairs of the Republic of Belarus and other agencies with a paramilitary structure are armed with cartridges (ammunition) 9×18Mak (51-N-181S) with a three-element bullet with a steel core. Replacement of the specified type of ammunition by the cartridge 9×18Mak (51-N-181) in which bullet the steel core is absent, does not change its properties at transfer from the category of fighting cartridges (ammunition) to the category "police". The 9×18Mak cartridge (51-N-181) was developed according to the Tactical and technical requirement No. 3110 of November 26, 1945. The main artillery Department of the Ministry of defense of the USSR in connection with the replacement of the cartridge (ammunition) 7.62×25 to the TT pistol and was adopted, but due to insufficient striking action was subsequently replaced by a cartridge 9×18Mak (51-N-181S) [57, pp. 165–190].

To substantiate the above point of view, it is necessary to refer to the works on the design of cartridges (ammunition), as well as the technical requirements for the complexes "weapon-cartridge" used in various fields (military, service, civil). At the same time, the main properties of rifle complexes "weapon-cartridge" are as follows:

1) *combat* designed to defeat manpower and equipment in the conduct of hostilities;

2) *civilian*-designed for sports, hunting, self-defense. Includes a hand-held small arms with a smooth or rifled bore; the design of bullets cartridges (ammunition) should not contain cores of solid metal, tracers, incendiary, explosive, other pyrotechnic compositions; powder charge cartridge (ammunition) is strictly regulated, provides a short range of the projectile element and reliable extraction of spent cartridges. The main requirement is safety in handling and reliability of operation;

3) *service*-is intended for use by employees of legal entities with special statutory tasks, which are permitted by law to carry, store and use these weapons in self-defense or performance of their duties by law. Should meet the technical requirements similar to those for civilian; for official purposes, as a rule, hand-held small firearms with muzzle energy of not more than 300 J [54, pp. 34–35].

Thus, the above confirms the conclusion that the division of cartridges (ammunition) depending on the scope of their application, established by The law "On Weapons", is not fully justified. The main criteria for attributing cartridges (ammunition) to a particular category are the features of their design and ballistic parameters of the throwing element when fired.

With regard to the topic of the study, we have developed a refined classification of cartridges (ammunition) used for shooting from hand-held firearms. When constructing the classification, the point of view of T. V. Averyanova was taken into account, according to which the process of building a forensic classification consists of three stages: 1) selection of a set of objects to be studied; 2) indication and precise definition of features, taking into account which the comparison will be made; 3) the method of differentiation of objects, i.e. the algorithm of their allocation in classes [2, p. 32].

At the same time, it is taken into account that the design of cartridges (ammunition) to manual small arms (regardless of the scope of its application) has minor differences, which allows you to apply a single system of classification. The following characteristics of the "munition — weapon — target" system were used as genus-specific features":

1) in relation to hand-held small arms-its intended purpose, the power of the muzzle energy, caliber, length of the barrel;

2) with regard to ammunition-the presence and type of striking (throwing) elements, the sleeve and its material; the method of initiation of the propellant charge and the location of the initiating substance or device; the method of manufacture;

3) characteristics of the vulnerability of the target, the environment of defeat.

The developed classification is based on the classification proposed by experts in the field of projecting cartridges for hand small arms by G. A. Danilin, V. P. Ogorodnikov and A. B. Zavolokin [54, pp. 42–45], which is refined taking into account the tasks of forensic science and the requirements imposed by the practice of forensic research of these objects.

Proceeding from the specified, depending on characteristic features of manual small arms firearms for firing from which cartridges (ammunition) are applied, they are classified as follows:

I. For the purpose of small firearms — ammo (ammunition):

1) to combat manual small arms firearms;

2) to service manual small arms firearms;

3) to civilian hand held small arms.

Classification on the specified basis is made taking into account such technical characteristics of the complex “ammunition — weapon” as the value of muzzle energy, and other design features welded elements, namely: the absence in the design of bullets to service and civilian small firearms cores of solid materials, significant deformation in the defeat of purpose, the impossibility of breaking through the individual means of body armor (a direct ban on the use of service and civilian weapons bullets into the design which are the cores of solid materials directly contained in the second paragraph of article 6 and the second paragraph of article 7 of the Law “On Weapons”).

II. Power of small firearms (the amount of muzzle energy) — the bullets (ammunition):

1) to hand-held small-bore firearms with low muzzle energy (<1000 J);

2) to manual small arms firearms with medium muzzle energy (1000–3000 J);

3) to hand-held small-arms firearms with large muzzle energy (>3000 J).

The criteria are based on the interrelated properties of a complex “ammo — weapon” as the value of the powder charge, barrel length, caliber of weapons, and other parameters considered the rate of internal ballistics.

III. According to the construction of trunk of small firearms — ammo (ammunition): 1) to rifled hand held small arms firearms; 2) to smoothbore hand-held small firearms.

IV. Along the length of the barrel of hand — held small arms-ammunition (ammunition): 1) to long-barreled hand-held small arms (>400 mm); 2) to medium-sized hand-held small arms (>200–400 mm); 3) to short-barreled hand-held small arms (≤200 mm); 4) to barreled hand held small arms.

V. By caliber of hand-held small-arms firearms-cartridges (ammunition) (except for cartridges for smoothbore hunting and barreled hand-held small-arms firearms): 1) small caliber (≤6.5 mm); 2) medium caliber (>6.5–9 mm); 3) large caliber (>9 mm–20 mm).

VI. According to the ratio of the diameter of the throwing element with the caliber of the barrel of a hand-held small-arms firearm, cartridges (ammunition): 1) caliber; 2) sub-caliber.

VII. Depending on the type of hand-held firearms-cartridges (ammunition): 1) pistol; 2) revolver; 3) intermediate; 4) rifle; 5) rifle.

VIII. By type of striking action of the thrown elements, — cartridges (ammunition) with the thrown elements: 1) simple (kinetic) action; 2) special action; 3) combined action.

IX. Depending on the speed of flight of the thrown elements-cartridges (ammunition): 1) with subsonic speed of the thrown element; 2) with supersonic speed of the thrown element.

X. By type of the thrown element — cartridges (ammunition): 1) with metal thrown elements; 2) with thrown elements from composite materials.

XI. By the number of striking throwing elements — cartridges (ammunition): 1) with one striking element; 2) with two striking elements; 3) with three striking elements; 4) with multiple striking elements.

XII. Depending on the properties of the environment — cartridges (ammunition): 1) for shooting in a gas environment (atmosphere); 2) for shooting in a liquid environment (under water); 3) for shooting in mixed conditions.

XIII. By the presence of the sleeve in the design of the cartridge (ammunition) — cartridges (ammunition): 1) sleeve (with metal, bimetallic, plastic and combined sleeve); 2) with a burning (pyrotechnic) sleeve; 3) unsleeved.

XIV. According to the method of actuating the means of initiating the propellant charge-cartridges (ammunition): 1) with shock initiation; 2) with electric initiation.

XV. On placement of initiating structure: 1) cartridges (ammunition) of the Central fight; 2) cartridges of ring ignition; 3) cartridges of lateral ignition (study).

XVI. Depending on the method of manufacture-cartridges (ammunition): 1) factory-made; 2) self-made; 3) partially or completely re-equipped with elements of cartridges factory-made (figure 2.1.5) [143].

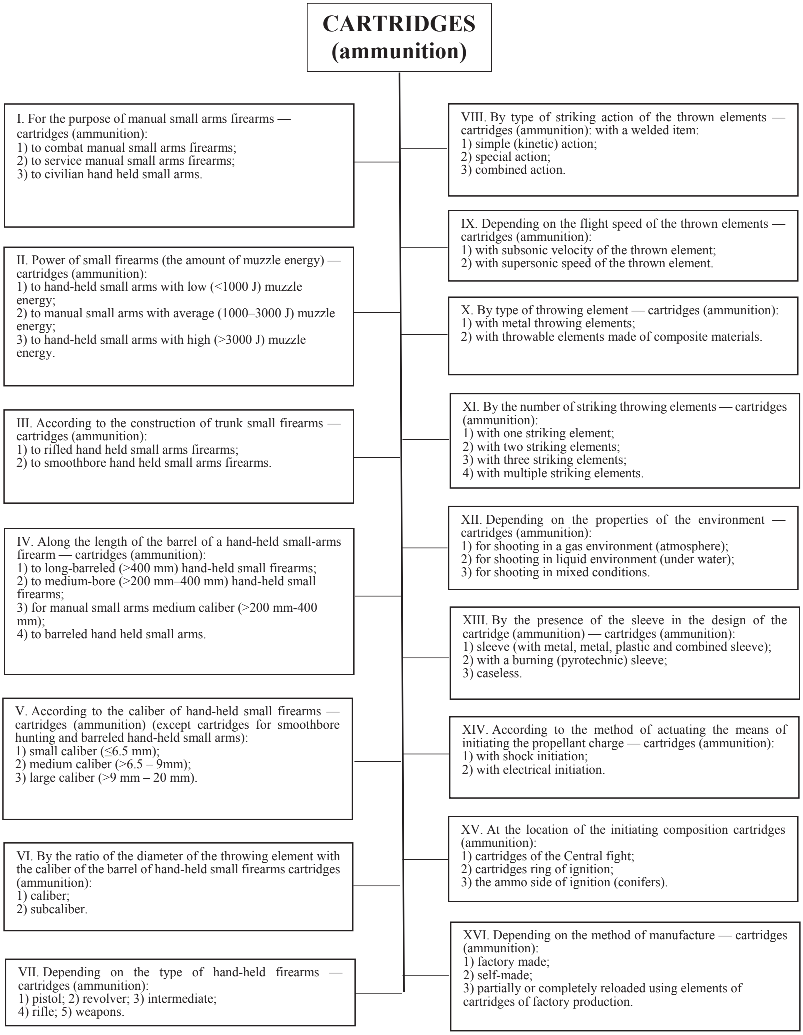


Figure 2.1.5 — **Classification of cartridges (ammunition) manual small arms firearms**

Compared with the existing classification more fully reflects the technical essence of cartridges (ammunition) as objects of forensic research. In addition, this classification is more informative, easier to navigate the variety of existing cartridges (ammunition), allows to predict ways to improve the design of these objects as a whole and their individual elements, facilitates the process of forensic investigation to determine the type (types) of the cartridge (ammunition), determine the type of small firearm, for firing from which they can be used. Nevertheless, it should be noted that the principle of relativity of the bases of any classification implies a deliberate insufficiency of their structure and classified objects. In addition, as already mentioned, the process of creating and improving the designs of cartridges (ammunition) is characterized by a certain dynamism. In this regard, the allocation of an exhaustive list of grounds for any classification is impossible in principle.

Thus, stated in this section of work allows to draw the following generalized conclusions:

1. The definitions of the term "munition" contained in the forensic literature do not fully meet the goals and objectives of forensic ballistic examination, since they do not sufficiently reflect the necessary set of features inherent in these objects of forensic research. The discrepancy between the terminology used in normative legal acts regulating the legal regime of firearms turnover and the terminology used in technical normative legal acts is due to differences in the purpose of the relevant terms and their definitions, in connection with which the use of terms contained in normative legal acts in the process of forensic ballistic examinations should be optional.

2. In the process of forensic ballistic research experts, in addition to the established theoretical and methodological provisions of forensic ballistics, should also take into account the provisions of technical regulations that establish the technical parameters and standards applicable to the processes of development, production, operation (use), storage, transportation, sale and disposal of hand-held small arms, as well as cartridges (ammunition) used for firing.

3. In order to eliminate the inconsistency of terms and their definitions contained in the Law "on weapons", and the relevant terms and their definitions used in other normative legal acts regulating public relations related to cartridges (ammunition) used for shooting from small arms, it is necessary to develop a unified terminological apparatus with

its consolidation in the methods of expert research for implementation in the practical activities of expert units. Taking into account the provisions of technical regulations, methods of forensic research of cartridges (ammunition) in improving the provisions Of the law "On Weapons" will increase the validity and reliability of the conclusions of forensic ballistic examinations.

4. With regard to the purposes of forensic ballistic examination, the following definition of the term is proposed: a munition of small arms is a single-action device, structurally provided and functionally designed to hit the target with a throwing element as a result of firing.

This definition reveals the essence of the concept of "ammunition" as an object of forensic research on the basis of the following defining its essence features: 1) functional (target) purpose; 2) structural security; 3) multicomponent; 4) single-use; 5) impact on the target as a result of firing a throwing element with a sufficient level of striking properties.

The proposed definition expresses the dialectical nature of the objective conditions, functional and constructive features of the object of forensic research, clarifies the terminology used in forensic science, the theory of forensic ballistic examination in order to accurately and uniformly understand the essence of these objects both in the process of forensic ballistic examination, and in assessing the reliability of the conclusions.

5. The analysis of the classifications of cartridges (ammunition) contained in the scientific literature on forensic ballistics and forensic medicine indicates the incompleteness of the bases used and the types of classified objects in relation to the tasks of their forensic research, which is due to the difference in forensic, technical and legal approaches to determining the properties of cartridges (ammunition) used for shooting.

6. As criteria of reference of cartridges (ammunition) to fighting, office, civil should serve not the technical signs of their device fixed in normative legal acts (in relation to the legislation of the Republic of Belarus — in the paragraph the second of article 6 and the paragraph the second of article 7 of The law "On Weapon"), and characteristics of system "ammunition — the weapon — target", which are the value of the muzzle energy and such features of the design of the projectile element of the cartridge (ammunition), as the absence of bullets in cartridges

(ammunition) to service and civilian weapons cores of solid materials tracer, incendiary, explosive or pyrotechnic compositions, as well as the vulnerability of the target.

7. The classification rounds (ammunition) used for shooting from manual small arms firearms designed AV-Thor based set of signs of the system “ordnance — weapons — target”, including the appointment of a cartridge (ammunition); the power of small firearms; the design of the barrel; barrel length; calibre; the ratio of the diameter of a welded element ka-librom a barrel; a hand of small firearms, which they used for firing; view of the damaging effect of methane element; the speed of his flight; the type of material from which it is made; the amount of methane elements in the design of the cartridge (ammunition); environmental characteristics of the lesion; presence of shells; a method of initiating a propellant charge; a method of manufacturing a cartridge (ammunition); the location of the initiating composition; the security objective means of individual protection.

2.2. Forensic properties and design features of cartridges (ammunition) for hand-held firearms

In the process of forensic ballistic examination of cartridges (ammunition) used for shooting from hand-held firearms, specific objects of the material world are investigated. Currently, a sample of hand-held small arms with a cartridge used in it for firing is considered as an integral complex “weapon — cartridge”, the elements of which have an impact on each other in the process of functioning.

The founder of the Soviet forensic ballistics V. F. Chervakov put forward the now universally recognized thesis that, along with the study of traces of hand firearms, cartridges (ammunition) to it, it is necessary to study their material part [281, pp. 5–6].

The cartridge (ammunition) provides realization of the main purpose of manual small arms firearms-defeat of the purpose. Currently, the process of improving small arms is characterized by the search for solutions to improve its effectiveness, the main of which is the improvement of the design of cartridges (ammunition) and its individual components [32, p. 7]. As noted in the literature, given that the operation of hand-held small arms is carried out only in the process of using it for firing cartridges (ammunition), the task of improving them is relevant, since they largely depend on its effectiveness. In this regard, the development of their design should go the way of increasing the action of projectiles at the target by improving all the constituent elements of the design of cartridges (ammunition) [288, p. 3].

The unitary cartridge as a complex product (device) is used in manual small arms since the middle of the XIX century. At the same time, to date, its design has not undergone any significant changes. In this period, the process of improving the manual small arms is characterized by the search for solutions to improve its efficiency, the main of which is to improve the design of cartridges (ammunition) and its individual components.

The analysis of literary sources testifies that considered earlier in separate works on judicial ballistic examination such perspective designs of cartridges (ammunition) as bezgilzovye, reactive, mnogopulnye, with an l-shaped sleeve, to manual small arms with an open chamber did not receive the further development, and works on development and improvement of their design were curtailed [56, pp. 27–90].

In connection with the significant development of science and technology, new types of cartridges (ammunition) have been developed, information about which is not available in the forensic literature. Based on this, it seems reasonable to consider ways to improve the design of cartridges (ammunition) and its individual elements, since this direction is currently dominant in the design of cartridges (ammunition) for handheld firearms.

For a long time the development of new samples of cartridges (ammunition) was carried out empirically with a focus on the practice of operation of similar products. In the 1970s and 1980s, on the basis of fundamental technical research, a rational system of projecting cartridges (ammunition) was developed, which began to use methods of ballistic calculations, evaluation of the effectiveness of action on the target, etc. Modern methods and developments of shooting complexes are based on data of internal, external and wound (terminal) ballistics, at the same time the system analysis and modern achievements of computer technology are used [242]. The need for such an approach is determined by the complexity of the design of cartridges (ammunition) and small arms, characterized by versatility, the use of new materials, the use of advanced technologies in their manufacture.

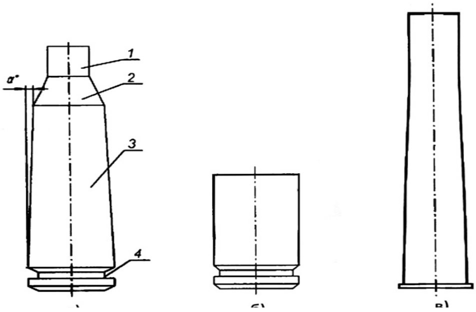
Taking into account the above, it seems reasonable to study not only the previously existing and modern samples of cartridges (ammunition) used for shooting from small arms, but also the promising directions of development of their design and its individual elements, which determine the properties acquired by them in the process of improvement, in relation to the tasks of forensic ballistic examination, since the process of creation and modernization of these objects of forensic ballistic research is continuous.

Historically, the unitary construction of the cartridge (ammunition) used for firing from small arms, as already stated, consists of four main components: the sleeve, the device initiating the propellant charge (primer-igniter), meta-tive charge (charge of propellant), methane element (part of the cartridge (ammunition) designed specifically to defeat the purpose). In addition to these elements in the design of the cartridge (ammunition) may also include optional elements (containers, wads, gaskets, etc.).

Within the framework of the studied question, it seems justified to consider each of these basic elements of a unitary cartridge (ammunition) in more detail.

Sleeve. At the present stage of development of the design of the cartridge (ammunition) one of its integral components is the sleeve. Its main purpose is to connect all elements of the cartridge (ammunition) in a single device, enabling the automation of the firing process, long-term preservation of the initiating composition and propellant from the effects of environmental factors, obturation of the chamber and the shutter arms of the breakthrough of the powder gases in the process shot, long-term storage of ammunition (for live ammunition in sealed packaging — up to 50 years, without compromising the basic properties) [54, p. 188; 90, p. 182].

In accordance with the GOST of the USSR 28653-90 “of Weapons. Terms and definitions” [190] depending on the form, there are three types of sleeves: 1) bottle; 2) cylindrical; 3) conical (figure 2.2.1).



a) b) c)

Figure 2.2.1 — **Sleeve shape:** a — bottle; b — cylindrical; c — conical; 1 — cartridge case muzzle; 2 — slope; 3 — body; 4 — bottom part; a^0 — the angle between the generator and the axis of the sleeve (cylindrical and conical sleeves are not marked)

Based on the functional purpose, each element of the cartridge case (ammunition) corresponds to a certain shape and size characteristics.

Cylindrical sleeves are named so conventionally, because, like the bottle-shaped sleeve, their body has a certain taper (a° = 0°30’...1°) to facilitate charging and extraction processes. The shape of the conical sleeve is transitional from cylindrical to bottle. Cartridges with a sleeve of this form were previously used in rifled hunting firearms, as well as some samples of pistols and revolvers (currently produced in limited batches). There are also casings with a reverse taper, but they are not used in cartridges for hand-held small arms.

In the device of the bottle sleeve there are four main elements: the muzzle, the ramp, the body and the bottom part. In cylindrical and conical sleeves the muzzle and the ramp are absent.

The muzzle of the sleeve serves for a strong fixation in it of the projectile (bullet) and improving the obturation of powder gases, in some samples of firearms with the help of the muzzle, the fixation of the cartridge in the chamber is provided.

Cartridge sleeve cut — end part of the sleeve from the side of its open part.

The ramp of the sleeve is a transitional section from the muzzle to the body and is designed for obturation of powder gases when fired, is a fixing element and a means of extinguishing the kinetic energy of the cartridge (ammunition) in the process of loading.

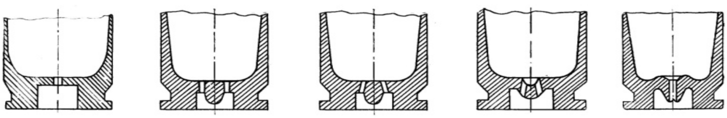
The housing of the sleeve is designed to accommodate the propellant charge and protect it from external influences, the upper part of the housing of the sleeve provides obturation at the time of the shot. The thickness of the walls of the shell casing from the top to the bottom gradually increases and increases at the bottom.

The bottom part of the sleeve is designed to place in it a device for initiating a propellant charge, locking the barrel channel, sending the cartridge into the chamber, reducing the deformation of the housing and the flange of the sleeve when firing. The inner surface of the bottom part of the sleeve may be flat or have a protrusion in the Central part, which houses the socket for the primer-igniter and the ignition holes for ignition of the propellant charge. Ignition holes are formed as a result of drilling or punching with needles. The outer surface of the bottom part of the sleeves is made flat, usually with embossed markings.

The bottom part of the sleeve may include a groove, flange, partition, ignition holes, primer socket, anvil and the end of the bottom part.

Cartridge case partition — a wall in the bottom of the cartridge case that separates the capsule socket of the cartridge case from the charging chamber.

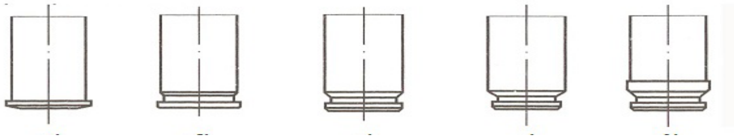
The bottom part of the non-metallic sleeve (for smoothbore hunting weapons) includes a pallet and the base of the sleeve.



a b c d e

Figure 2.2.2 — **Main types of construction of bottom part of sleeves (in a section):**
a — with capsule socket without anvil;
b — with anvil and two vertical firing holes;
c, d — with anvil and two inclined ignition holes;
e — with one ignition hole in the anvil

In the form of the bottom part is allocated: 1) flange (Welt) (with full-size and partially protruding flange); 2) flangeless (Weltless); with a small flange; with an annular projection (figure 2.2.3).



a b c d e

Figure 2.2.3 — **Cartridge cases with different bottom shape:**
a — with a full-size flange (R); b — with partially protruding flange (SR);
c — flangeless; d — with a small flange (r); e — with annular projection (B)

According to the European standard C. I. P. of the Permanent International Commission for testing of hand-held firearms (PMK), the name of the cartridge indicates its caliber, the length of the sleeve in millimeters, as well as the presence of a protruding flange (Rant (R) — the protruding flange). Less often specified type of weapon, the purpose of the cartridge and the weight of the bullet (Browning (Br) — weapon model).

Example:

7,62×54R — 7.62 mm rifle cartridge to 7.62 mm Mosin design rifle with 54 mm sleeve length and protruding flange;

7,65×17SR or 7.65×17Br — 7.65 mm pistol cartridge with a sleeve length of 17 mm with a partially protruding flange (Semi Rimmed (SR) — sleeve with a partially protruding flange);

6,35×15Br or a 6.35×15.5 — 6.35 mm pistol cartridge with a 15.5 mm sleeve length with a partially protruding flange;

9×18 Mak — 9-mm pistol cartridge to 9-mm pistol Makarov design with a sleeve length of 18 mm.

If the cartridge has several well-established names, including in countries where the American and English designation systems are used, then it is advisable to indicate its second name in the text of the examination.

Example:

5,6×16R (.22 LR) — 5.6-mm sport-hunting cartridge ring ignition with a sleeve length of 16 mm and a protruding flange (Long Rifle (LR) — long screw-tow) to 5.6-mm Margolin pistol, 5.6-mm TOZ rifle -8;

7,62×63 (.30-06 Springfield) — hunting cartridge for M1 Garand self-loading rifle, hunting carbine "Ceska Zbroevka" CZ 557 with sleeve length 63 mm;

6.35×15Br (.25 ACP*)* — 6.35-mm pistol cartridge with 15.5 mm sleeve length with partially protruding flange.

The method of fixation in the chamber distinguish cases with emphasis (figure 2.2.4): cut housing sleeve to the ledge of the chamber (with its cartridge case in the Cup in the chamber); stingray in the chamber Stingray; a ledge on the body of the sleeve in the bore of the breech of the barrel; a flange recess in the breech; partially protruding flange in the breech muzzle.

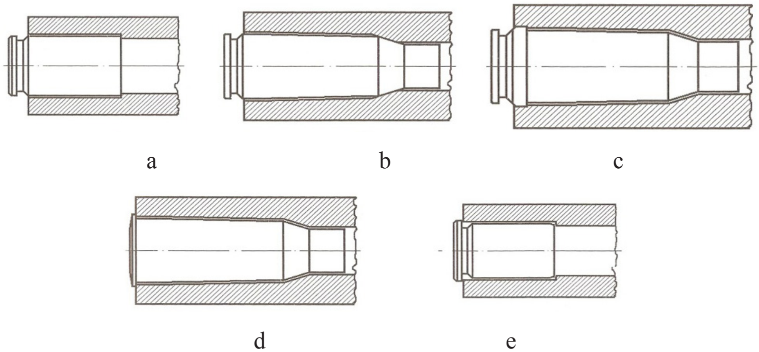


Figure 2.2.4 — **Fixation of the sleeve in the chamber of small arms firearms:** a — cut the shell casing in the chamber ledge; b — Stingray in the chamber Stingray; c — ledge on the body of the sleeve in the recess of the breech of the barrel; d — flange into the recess of the breech of the barrel; e — partially protruding flange into the breech section of the barrel

Depending on the design there are two types of cartridges for firearms: a) seamless (one-piece) and b) collapsible. At the same time, prefabricated sleeves with a polymer and cardboard body are used mainly in the design of cartridges (ammunition) for hunting smoothbore weapons.

According to the material of manufacture sleeves are divided into: a) sleeves made of metal construction materials (low carbon steel, brass, bimetal); b) sleeves made of non-metallic materials (cardboard, polymeric materials); c) sleeves burning (pyrotechnic).

Cartridge cases with a body made of polymeric materials are used primarily in cartridges for smoothbore hunting weapons and weapons with limited striking ability (traumatic weapons) [54, p. 192].

One of the main elements of the cartridge equipment for smoothbore hunting hand-held small arms is the choice of the type of sleeve used in it, among which there are: sleeves with a polymer body; sleeves with cardboard body; all-metal sleeves; all-plastic sleeves.

Currently a significant number of cartridges for smoothbore hunting hand held small arms are equipped with the use of a sleeve with a polymer body. The design of such a sleeve contains a metal base, a housing (polymer tube) and a pallet (figure 2.2.5).

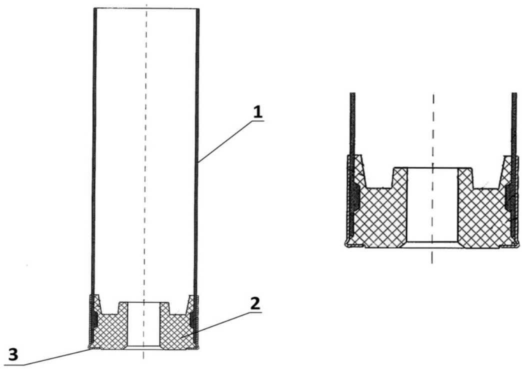


Figure 2.2.5 — **The device of the collective cartridge case to the smoothbore hunting weapon:** 1 — housing (polymer or cardboard tube), 2 — liner tray, 3 — the base of the sleeve; **enlarged fragment of the base of the sleeve**

In the development and manufacture of cartridges (ammunition), designed for shooting from smoothbore hand-held small hunting weapons, the following features are taken into account in the industry:

the dimensional characteristics of the cartridge, subject to control from a security point of view, as well as the main part of the dimensions to be controlled from the point of view of typical supplies determined by the container size;

the internal dimensions of the sleeve are not standardized and may vary depending on the manufacturer;

the landing diameter of the capsule socket of the sleeve is not normalized and is determined by compatibility with the primer-igniter;

the primer-igniter is installed in the primer socket with a force that excludes the possibility of its displacement when fired, deformation and destruction of the pressing of the initiating composition;

the primer-igniter is installed in the capsule socket of the cartridge sleeve until it stops, thereby eliminating the possibility of losing part of the energy of the striker with his knee pads.

The metal base is made by stamping a steel strip 0.3–0.4 mm thick, covered with tompak. Obturation of powder gases at a shot from manual small arms firearms is provided at the expense of increase in diameter of the metal basis up to the stop in walls of a chamber and restoration of the initial size after pressure removal. With a sufficiently significant residual plastic deformation, the diameter of the metal base after the shot can remain increased and prevent the free extraction of the spent sleeve from the chamber of the hand-held small arms, creating favorable conditions for trace formation. In this case, removing the spent cartridge case may require considerable effort. In this case, the low strength of the sleeve flange in combination with a small area of the ejector gun can cause deformation of the flange and the ejector failure, after which the extraction of the spent sleeve is possible only with the help of a ramrod from the muzzle of the barrel.

The weakening of the design, due to the reduction of the strength of the sleeve body to the metal base, can cause the dismantling of the sleeve, which, in turn, can be accompanied by ejection of the sleeve body from the barrel or its jamming in the chamber or the barrel channel. The case of the sleeve stuck in the chamber can prevent infection of the next cartridge or its extraction. The body stuck in the barrel channel, although it does not prevent the loading of the next cartridge, during the production of the shot can lead to a rupture of the barrel of the weapon.

The polymer body of the cartridge case of hunting cartridges (ammunition) to smoothbore hunting hand-held small arms, as a rule, is made of polyethylene. The thickness of the shell wall is about 0.7–0.8 mm; the inner diameter for 12 gauge sleeves varies between 18.6–18.8 mm. In most cases the liner pallet is also made of polyethylene by injection molding.

In the industry, sleeves with a metal base height of 8, 12, 16 and 25 mm are widespread, sleeves with a metal base height of 20, 22 and 27 mm, respectively, are less common. In this case the actual height of the metal base of the sleeve may differ from the nominally installed in the processing ±1 mm. The height of the pallet for all sizes of sleeves in most cases is 10–12 mm. Sleeves, the height of the metal base of which is about 8 mm, are used for equipment of mass sports and cheap hunting cartridges. Liner with metal base height of 12 mm can be used for equipment sporting and hunting weapons; core height 16 mm — for equipment of cartridges are high quality cartridges with a length of 76 mm Magnum and 89 mm "Supermagnum"; core height 20 to 27 mm — only for equipment of cartridges of the highest class.

In most cases, the designation of the sleeve size includes the caliber, the length of the body and the height of the metal base. For example, the designation 12-76-16 or 12/76/16 refers to the cartridge case of a hunting cartridge to a 12-gauge smoothbore hand-held small-arms firearm with a body length of 76 mm and a metal base height of 16 mm.

The polymer casing of the sleeve can have different colors, be colorless, transparent and opaque. Sleeves with colorless transparent polymeric cases are used, as a rule, for equipment of hunting bullet cartridges (ammunition) of high price category.

Currently in industry there is a restriction on the use of sleeves with a polymer body of yellow color when equipping cartridges. For cartridges of 20 caliber to smoothbore hunting manual small arms the sleeves with the polymeric case of only yellow color shall be used, cartridges of other calibers can be equipped with use of sleeves with tubes of any color, except yellow.

In addition, the sleeves can be both with an inner cone and without an inner cone. This choice is determined by the proposed method of sealing the housing of cartridges in their equipment.

Sleeves without inner cone are designed for circular rolling of cartridges. The use of such sleeves for rolling multibeam star (rolling type "star") does not allow to provide a stable shape, the minimum diameter of the central hole, increases the probability of deformation, crumpling, overlap of the rays of the star.

Sleeves with an inner cone are designed for rolling cartridges with a multibeam star. The use of such sleeves for circular rolling is possible, but does not allow to provide a stable shape and increases the probability of deformation of the rolling due to the crumpling of the conical part of the body.

Sleeves with a cardboard case differ in design from sleeves with a plastic case only in the material used, they can use a cardboard pallet. For a long period of time, before the advent of high-strength polymer materials, sleeves with a cardboard body were the main type of sleeves, but later they were replaced by sleeves with a polymer body. Now their production is resumed first of all for cartridges of 12 caliber. The main advantage of sleeves with cardboard body is temperature stability in a wide temperature range. However, despite the coating with a moisture-proof varnish, the cardboard case is exposed to moisture. Swelling of cardboard under the action of moisture can occur in conditions unacceptable for the storage of cartridges, causing at the same time also intense corrosion of the metal base of the sleeve and the primer-igniter.

Metal hunting cartridges are available in two types: the Central battle (OMC) and zhevelo (OMJ) — for equipment of cartridges of calibers 10, 12, 16, 20, 28, 32 produced in the USSR, now in the Russian Federation. The OMC inner anvil type cartridges are designed for use with Central battle primers for hunting rifle cartridges (CBOs). OMJ type sleeves without internal anvil are intended for use with primers-igniters "Zhevelo".

The average resource of a metal sleeve should be at least 20 shots. In this case, such sleeves are subject to residual plastic deformation, in connection with which in most cases, after each shot, it is necessary to restore their shape with the help of a special mandrel. However, the main problem with the use of metal sleeves is the impossibility of using wads, obturators, gaskets and other auxiliary equipment elements intended for use in sleeves with a plastic body due to the difference in internal diameters. For example, the inner diameter of a 12 gauge metal sleeve is 19.3–19.4 mm, which is significantly larger than the inner diameter of a similar caliber sleeve with a polymer body.

Metal sleeves have no industrial application, are used in small quantities by hunters for equipment of cartridges in house conditions.

The materials used for the manufacture of all-stamped metal sleeves for rifled hand-held small arms are subject to requirements determined by the process of their manufacture and operation of cartridges (ammunition). Currently, it is established that the best in terms of compliance with the requirements are brass grades L68 and L70. However, we note the high cost of such cartridges, the tendency to corrosion changes, which complicates their long-term storage (requiring the duration of storage in a sealed metal seal, without loss of performance and a slight decrease in ballistic properties for at least 40 years — for cartridges for combat hand-held firearms). The interaction of alloy elements (brass) — copper and zinc with ammonia and mercury vapor, which are components of propellant charges and initiating substances of primers, leads to oxidation of the metal and the appearance of microcracks. In order to reduce the impact on the sleeve material, inert coatings (varnishing, phosphating, Nickel plating) are used.

At present, low-carbon steel grades 11UA and 18UA are recognized as cheaper and non-scarce material, not prone to external influences. However, the production of sleeves made of such material requires the use of wear-resistant tools, anti-corrosion and anti-friction coatings.

To simplify the technological process of manufacturing steel sleeves as a solid lubricant used tompak in the form of a double coating thickness of 4–6 % of the thickness of steel products. At the same time, it is quite difficult to maintain the continuity of tompak coating on the entire surface of the steel sheet, in connection with which the enterprises of the Russian Federation are now widely used varnishing cartridges of mass production, which simplifies the production cycle and reduces the cost.

The tendency to use polymeric materials in the production of cartridges (ammunition) can be traced in the production of cartridges for both civilian and military hand-held small arms, which is explained by the desire to reduce the mass of cartridges (ammunition), simplify the technological process and reduce the time-consuming costs for the production of cartridges of this type.

In particular, in the process of improving self-defense systems, which include traumatic pistols: PB-4 “WASP”, PB — 2 “WASP-aegis” and Mr — 461 “Guard” — developed cartridge 18×45T with a polymer sleeve [199]. The sleeve of this cartridge is assembled, produced by injection molding into a mold; the bottom part of the sleeve is made of stainless steel by stamping and is attached to the body of the sleeve by rolling. On the inner surface of the housing section of the sleeve are ready inclined rifling designed to stabilize the bullet rotation. At the moment of a shot the bullet at interaction with a rifled part of the case of a sleeve acquires rotational-translational movement, than stability of its flight on a trajectory is provided (figure 2.2.6).

a b

Figure 2.2.6 — **Cartridge 18×45T “A+A” with polymer sleeve:**
a — General view of the cartridges (left-rubberized throwing element);
b — scheme to ensure stabilization of the bullet cartridge flight 18×45 “A+A” [199]

For cartridges (ammunition) used for firing from combat hand-held small arms, sleeves made of polymeric materials are practically not used, since the physical and chemical properties of polymeric materials can vary depending on the ambient temperature, as well as heat dissipation when basing the cartridge (ammunition) in the chamber of automatic firearms to exclude self-ignition of the propellant charge. According to the military standards of the North Atlantic Treaty Organization (NATO), the propellant charge of a cartridge (ammunition) should not self-ignite when it is sent to the chamber of a hand-held small-arms firearm after a continuous production of 150 rounds [56, p. 207]. However, the American PCP Ammunition Company currently produces cartridges with a 5.56×45 NATO, 6.8×43 SPC, 7.62×51 NATO, 8.6×70 (.338 Lapua Magnum) and 12.7×99 NATO (.50 BMG), the casing of which is partially made of polymeric materials [197]. Испанская компания Extreme Polymer Research [196] developed a range of cartridges (ammunition) with a fully polymer sleeve, the operating temperature range of which is from –40 °C to +150 °C.

With regard to the expert study of cartridges (ammunition) used for firing small arms, it should be borne in mind that the use of polymeric materials as a material for the manufacture of cartridge cases can significantly complicate the process of identification research. As the expert practice shows, traces of weapon parts formed on polymeric materials as a result of preparatory, accompanying and completing shooting phenomena, processes and operations, although they have a set of identification features, as a rule, have a low contrast compared to the "background", which complicates the process of photographing them without special preparatory techniques and operations to enhance the contrast of individual features of the traces on the object under study. Besides, high quality of processing of trace-forming elements of a design of modern samples of manual small arms considerably complicates detection of characteristic individual features that leads to impossibility of identification of a concrete copy of manual small arms from which the shot was made [97, pp. 74–80; 239].

Russian scientists N. Yu. Goryacheva, A.V. Fedin, V. A. Fedorenko, E. A. Chashchin proposed a method for applying mechanically or with a laser additional identifiers in the form of forensic labels (barcodes) on the details of hand-held small arms involved in the process of trace formation on the cartridge case (ammunition) in the production of the shot. The analysis of the results obtained during the experiments clearly shows that at present the presence of such marking significantly facilitates the process of forensic identification of civil and service small arms firearms by traces on the elements of cartridges (ammunition) [48, pp. 63–103; 268, pp. 56–58].

The sleeves of all industrially produced cartridges (ammunition) for rifled small arms allow their use in self-loading (automatic) weapons, while the speed of the cartridge into the chamber reaches in some cases a speed of about 10–15 m/s. Arising as a result of this process, inertial forces can destroy the housing of the cartridge (ammunition) and cause the cartridge to settle (premature exit of the bullet from the housing or the muzzle of the sleeve with a possible precipitation of the propellant charge). To eliminate this phenomenon, certain methods of fixing the bullet in the sleeve are used: tight fit (the bullet is held in the casing by friction); core (round or rectangular core); rolling the edge of the body (muzzle) of the sleeve into the annular groove of the bullet body; crimping the body (muzzle) of the sleeve into the annular groove; combined (combination of the above techniques) (figure 2.2.7).

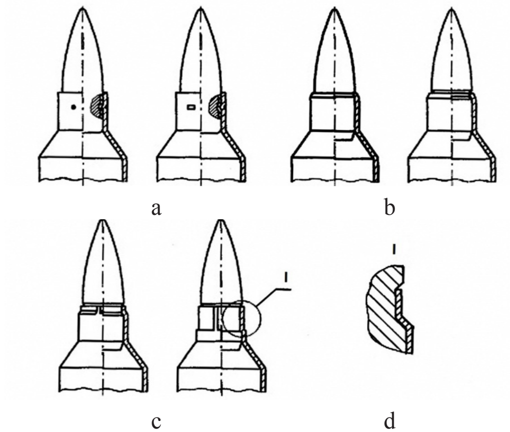


Figure **2.2.7 — Fixing the bullet in the cartridge case (ammunition):**

a — core gun muzzle; b — rolling the muzzle; c — muzzle crimp;
d — attachment fragment [54, p. 251]

The value of the bullet-extracting force in cartridges (ammunition) used in modern hand-held small arms is 190–1200 H [90, p. 201], which provides the necessary strength of the bullet attachment in the cartridge case, as well as the achievement of the required value of the forcing pressure.

Connection of elements of equipment of the cartridge (ammunition) to smoothbore hunting manual small arms in sleeves with the polymeric and cardboard case is provided by deformation of the case (rolling). The casings of hunting shotgun cartridges can be rolled by a multipath star (rolling "star") or circular rolling. This takes into account certain features.

First, multibeam star rolling cartridges must be of fixed length. A necessary condition for reducing the rays of the star in the center of the rolling with a minimum diameter of the Central hole is the deformation of the portion of the sleeve body of a strictly defined length, depending on the caliber. For example, for 12 gauge cartridges, the length of the deformable portion of the sleeve body is 11 mm, therefore, a 12/70 caliber cartridge should always have a length of about 59 mm, a 12/76 caliber cartridge should have a length of 65 mm, etc. Thus, the length of the deformable portion of the shell casing decreases with decreasing caliber of the cartridge.

Secondly, for the equipment of cartridges with multibeam star rolling in the industry, sleeves with an inner cone are used, which is a necessary condition for a stable rolling shape with a minimum diameter of the central hole. The use of sleeves without an inner cone is associated with an increase in the number of cartridges with various rolling deformations, overlapping of star beams, unstable diameter of the central hole. In addition, if the diameter of the central hole is unstable, it is possible to pour small fractions through the central hole.

Circular rolling cartridges have a limited maximum length. The maximum length of the cartridge is determined by the length of the deformable portion of the muzzle of the sleeve required for complete rolling. The length of the deformable section of the sleeve muzzle for complete rolling depends on the thickness of the sleeve body, on the caliber and is 5.0–5.5 mm. Thus, the maximum length of a 12/70 caliber cartridge should not exceed 64.5 mm, a 12/76 caliber cartridge should not exceed 70.5 mm, etc.

Circular rolling, made with defects, leads to a weakening of the cartridge design and significantly increases the probability of precipitation of the shot when hitting and dropping the cartridge, as well as as a result of the impact of inertial loads on the shot when firing multi-shotguns. The minimum length of cartridges with circular rolling has no clear restrictions and is determined only by the possible deformation of the rolled part of the sleeve body in case of excessive rolling depth. In most cases, there are no problems associated with circular rolling, with a rolling depth of up to 10 mm.

The small length of the deformable section of the sleeve body allows a significant increase in the length of large caliber cartridges. This causes an increase in the volume occupied by the fraction, and, accordingly, the mass of the fraction. The absence of strict restrictions on the minimum length of cartridges with circular rolling allows you to equip hunting cartridges (ammunition) caliber 12/70 shot weighing 32, 34, 36, 38, 40 and 42 g.

Devices for initiation of propellant charge (primer-igniter). To initiate the chemical transformation of the propellant charge of the cartridge (ammunition), initiation means (primers) are currently used, structurally representing a shell (cap) in which a substance or a mixture of substances sensitive to external impulses — shock, puncture, heating, friction [86, pp. 4–5].

Primers are designed to create a thermal pulse in the form of a beam of fire to communicate its propellant charge of the cartridge (ammunition). Caps-igniters must operate reliably from the impact of the striker, i.e. have sufficient sensitivity-the ability to operate from the impact of a certain force. At the same time caps-igniters have to be safe in the address, equipment and loading of manual small arms, have a certain flammable ability (power) rendering reliable monotonous influence on a propellant charge of a cartridge (ammunition). The primer-igniter must provide a beam of fire of a certain length, duration of action and strength. The length of the flame force, the duration of its action and the force are combined by the term “flame force”, which is the defining characteristic of the primers. The best initiating ability is possessed by primers-igniters forming the greatest force of the flame.

Ignition of the propelling charge with primer-igniter is not instantaneous, and for some time. To ignite the powder charge, it is necessary to heat it to the appropriate temperature. The stronger the igniting impulse, the sooner the process proceeds. Black powder is ignited relatively easily. Smokeless gunpowder is more difficult to ignite and requires powerful means of initiation. At the same time, the greater the propellant charge, the more powerful the igniter is required for it. At independent equipment of cartridges to the smoothbore hunting firearms used in the conditions of low temperatures, hunters strengthen the primer-igniter with 5–6 grains of smoky powder that gives an increase of a force of a flame and improves Flammability of a propellant charge of smokeless powder.

A relatively weak primer igniter can cause a prolonged shot, i. e. a shot that does not occur immediately, but after a certain period of time after the strike of the striker on the cartridge's cap. In this case, the beam of fire ignites only the nearest layers of gunpowder, and further layers ignite from the first after a certain period of time. Such ignition can lead to local high pressures, and sometimes to rupture of the barrel of the weapon. This is all the more dangerous because the shot can occur after opening the gun.

The use of a more powerful primer-igniter can cause an increase in the initial velocity of the thrown element and an increase in the pressure in the channel of hand-held small arms, which can also lead to the above undesirable consequences. In this regard, usually try to avoid the use of cartridges (ammunition) as weak and overly powerful primers-igniters.

In cartridges (ammunition) to modern manual firearms, depending on the method of production of the shot from it, primers are used: 1) shock initiation; 2) electrical initiation (their design contains elements that convert electrical energy into heat).

In percussion initiation primers (the most common), the triggering mixture is triggered by the dynamic compression of the striker's striker on the anvil. The main composition used in the equipment of percussion caps-igniters is a mixture of explosive mercury (initiator), potassium chlorate (oxidizer) and antimony tri-sulfur (fuel) [86, pp. 13–14]. However, this mixture causes corrosion of the barrel of the weapon when fired, resulting in reduced resource weapons as a whole. In order to eliminate this disadvantage, initiating compositions that do not cause corrosion of the trunk were used, as initiators in which lead trinitroresorcinate or dinitrodiazophenol were used [54, p. 274]. In particular, the cartridge 5.45×18, used for shooting from a pistol self-loading, small-sized (PSM), used neorzhavlyayuschy capsule composition of the following composition: teneres (15 %), tetrazene (2 %), bertoletova salt (42 %), antimony sulfide (41 %) [57, p. 192].

Cartridge primer-igniter (figure 2.2.8) is a solid metal shell (cap), which is pressed into the composition, sensitive to impact. On top of the structure for protection from external influences is closed by a metal foil or parchment, sometimes the composition of the cover layer of varnish.

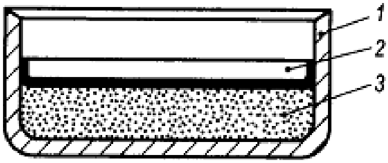


Figure 2.2.8 — **Scheme of the device of the primer-igniter "Berdan":**
1 — shell (cap); 2 — cover; 3 — impact

The shell (cap) is made most often of copper; it must have a strictly defined shape and size for the outer and inner diameters, height, and thickness of the walls and bottom. The shell (cap) must be made of a material that does not interact with the components of the shock composition, and must ensure the safety of the capsule during storage and use. When fired, the shell (cap) of the cartridge primer-igniter must remain intact and thus prevent the breakthrough of gases through its walls and bottom, as well as at the junction of the shell with the edges of the capsule socket (breakouts around the circumference). The bottom of the shell (cap) should not break through from the impact of the striker.

In addition, the shell (cap) should be tightly included in the capsule socket of the sleeve, and after the shot is somewhat distributed and tightly fit to its walls.

The shell (cap) of the cartridge primer-igniter (figure 2.2.8) is made by stamping from sheet metal. The shape and outer dimensions of the shell (cap) are determined by the shape and size of the capsule socket of the sleeve. The outer diameter of the shell (cap) and its height should be of such dimensions as to ensure a tight entry of the capsule into the capsule socket of the sleeve and to prevent both the dropout of the capsule from the sleeve and gas breakouts along the circumference. The thickness of the bottom and walls of the primer-igniter is determined by the pressure of the powder gases when fired and the force of impact of the striker of the weapon. In case of application of too thin shell, gas breakouts and penetration of the primer-igniter, as well as excessive sensitivity of the latter to impact, are possible. The thickening of the shell leads to a decrease in the sensitivity of the primer-igniter.

When striking the striker on the bottom of the primer-igniter, the shock (initiating) composition ignites, the beam of fire through the seed holes in the partition penetrates into the charging chamber of the sleeve, the powder ignites and the shot occurs. The sleeve itself serves as an obturator preventing the possibility of gas breakthrough to the gate. At a shot it is distributed, rests a bottom part in a gate mirror, densely adjoins walls of the case to chamber walls, thereby preventing break of gases towards a gate. The retention of gases from breaking through to the bolt through the firing holes is provided by the primer cap, which should sit tightly in the primer socket and remain intact when fired.

The inner diameter of the capsule shell is determined from the difference between the outer diameter and the thickness of the two walls. From the inner diameter and depth of the shell depends on the internal volume in which the charge of the shock composition is placed.

Currently, for the shells of cartridge primers, brass and copper are used in the form of thinly rolled tapes with certain mechanical properties that provide ease of manufacture of the shell, its strength and proper sensitivity of the capsule to impact. Too hard metal will prevent the striker from advancing and weaken its impact, which can reduce the sensitivity of the primer.

Shells for caps pistol, revolver and rifle cartridges are made of brass. Copper is used for the shells of hunting capsules. The use of iron for these purposes is more economical than other metals, but due to the rapid corrosion of iron in a humid atmosphere, iron shells are unsuitable for long-term storage. Attempts to use such shells for hunting primers were not successful, given the reduced sensitivity of the caps to the impact of the striker due to the hardness of iron.

To protect against corrosion, iron caps are plated with a layer of non-ferrous metal-tin, honey or zinc. Zinc coating is the most economical and at the same time has sufficient resistance. Copper shells are coated with a layer of tin (tinned) or Nickel-plated, and sometimes oxidized.

As coatings for the shock composition in cartridge primers, igniters use mugs of thin metal foil, and sometimes from vegetable parchment, the side of which, facing the shock composition, for better adhesion to it is varnished with shellac-rosin alcohol or nitrocellulose varnish. Vegetable parchment is used to reduce the sensitivity to the impact of some varieties of capsules, as well as in order to save. Paper circle varnished and on the outside. In some cases when using foil circles also varnish the joint of the mug with the inner walls of the cap. The total thickness of the coating, composition and bottom of the shell is called the height of the shock composition.

For military cartridge primers, igniters use mugs of thin foil made of pure tin with the addition of antimony (2–3 %) to give rigidity. Lead foil clad with a layer of tin is used for primers of cartridges for hunting hand-held small firearms.

Foil or paper circle should have a certain diameter and a certain thickness for each class of primers. The diameter of the foil mug is determined by the inner diameter of the cap, and the thickness of the foil is determined by the sensitivity of the primer to impact. With the thickening of the foil, the sensitivity to shock decreases, and Vice versa.

For the best fixing of shock structure an internal surface of a cap varnish. The installed suspension of the shock composition of a given formulation is pressed under a certain pressure.

The main element of the primer-igniter is the shock (initiating) composition, which must be sufficiently sensitive to impact and at the same time safe in the manufacture and handling of it. The flame force must be of sufficient power to ensure ignition and normal combustion of the propellant charge burning. In addition, the shock (initiating) composition must be resistant to storage and not to enter into chemical interaction with the metal shell and coating, and the combustion products of the shock (initiating) composition must not have a harmful effect on the material of the barrel of hand-held firearms.

The monotonous action of cartridge primers is provided by the monotony of the formulation used, the mass of the charge and the degree of compression of the shock composition.

Currently known initiating explosives in pure form are unsuitable for the equipment of primers, because they have a high sensitivity to impact and do not form a beam of fire necessary for the ignition of gunpowder. Being substances with significant high-explosive properties, they are characterized by short-term action.

Used for charges smokeless gunpowder require a strong and relatively long exposure to the flame. Therefore, along with the initiating explosives, as sensitive to impact, so-called *regulatory impurities* are introduced into the shock compositions, reducing the high-explosive action of the initiator and at the same time giving a sufficient beam of fire for ignition of gunpowder and other explosives.

As regulatory impurities are used primarily combustible substances, which during combustion emit the necessary amount of heat and create the required for ignition of gunpowder beam of fire. From combustible substances are selected such, the combustion of which remains a large number of solid particles. The particles hit the propellant charge, thus providing the strength and duration of the fire beam. Under similar conditions, a greater Flammability is possessed by the shock composition, which, when ignited, forms a greater number of solid particles heated to a high temperature. Solid particles, having a higher density compared to gases, contain a greater amount of heat per unit volume, and therefore are able to quickly heat the particles of the flammable substance to the ignition temperature.

In addition, as regulatory impurities used substances that reduce or increase the sensitivity of the composition — *phlegmatizers and sensitizers*; substances binding to individual components of the mixture — *cementators*, as well as substances that neutralize acidic decomposition products that can be formed during storage — *stabilizers*. For complete combustion of all elements of the composition, oxygen-rich substances — *oxidizers* — are introduced into it.

Thus, the impact composition is a mechanical mixture consisting of an initiating explosive, or initiator, and regulatory impurities containing fuel and an oxidizer as mandatory components. Phlegmatizers, sensitizers, cementators and stabilizers are not mandatory components and are introduced into formulations as needed. In capsule, the composition may be added substances, reducing the temperature of combustion shock structure.

The components of the shock composition must be taken in a certain ratio and with a certain amount of their crystals, and carefully mixed together to obtain as homogeneous a mixture as possible, since the sensitivity of the shock composition and its flammable ability depend on this.

When choosing the formulation of the composition in the production of primers, the following circumstances are taken into account:

1) the lower the brisance of the shock composition, the better its Flammability;

2) the greater the pressure created by the products of the explosion, and the higher the temperature of these products, the better the Flammability of the primer-igniter;

3) the least explosive shock compositions emit the greatest amount of heat and have the highest temperature of solid combustion products;

4) percussion compositions containing the largest amount of initiator have the greatest brisance;

5) the longer the flame beam of the primer-igniter formed by the shock composition, the more reliable the ignition of the propellant charge [86, p. 13].

Increasing the length of the beam fire of the primer-igniter is often hampered by the fact that the greatest length of beam fire give shock most blasting compositions containing the products of combustion, fewer particulates.

Currently, the shock compositions consist of a mixture of three components: bertolet salt ($KClO_3$), rattlesnake mercury ($Hg(CNS)_2$) and antimony sulfide (Sb_2S_3) in various ratios. In the shock composition, mercury is the initiator, potassium chlorate is the oxidizer, and antimony sulfide is the fuel.

Rattlesnake mercury and potassium chlorate are manufactured in factories, antimony sulfide is used exclusively of natural origin, occurring in nature in the form of an ore called antimony luster or antimonite [86, p. 13].

To increase sensitivity, finely ground glass and emery were sometimes added to the composition, and gelatin, shellac, gum arabic and artificial resins were added to reduce sensitivity and as cementators. Currently, shock compositions are prepared mainly without additives, greatly complicating the production process, avoid the use of glass in shock compositions, since it increases the danger in production [86, p. 14]. The sensitivity of the composition is changed depending on the degree of grinding of antimony sulfide-a solid with sharp-angled crystals. For each class of primers, both the percentage ratio and the size of the crystals (grains) of the components of the initiating mixture are established. To calculate the percentage of these components come from the reaction of their decomposition, but in practice it may vary depending on the purpose (type) of the primer-igniter.

Explosive mercury-chloride compositions with antimony sulfide are sufficiently sensitive to shock and heat, safe in manufacture, give the necessary flame beam for ignition and safe in storage. The main drawback of these compositions is that they have the ability to interact with some metals, and the products of their combustion act both on the barrel of a hand firearm and on the cartridge case. The effect of chlorate compounds on the metal of the barrel of the weapon was noticed in the first period of the appearance of primers: the barrels of capsule guns required more care than the barrels of flintlocks. The survivability of the barrels of hand held small arms has especially deteriorated with the beginning of the use of smokeless gunpowder for shooting.

A detailed study of this phenomenon showed that the deterioration of the survivability of weapons is the result of the harmful effects not only of the combustion products of smokeless powder, but also of the combustion products of the percussion cap composition burning. When firing smoky gunpowder, this phenomenon was weakened, since the carbon of smoky gunpowder reduced the harmful effect of the combustion products of the capsule composition, partially neutralizing them.

Combustion products of smokeless powder are not able to neutralize the combustion products of capsule compositions burning. In addition, the ignition of smokeless gunpowder required a more powerful primer composition than for smoky, which significantly increased the effect of combustion products on the bore of the weapon [86, p. 15].

The decomposition reaction of greatertoronto impact of the structure can be represented in the following equations:

$$3Hg(CNO)_2 + 2KClO_3 \rightarrow 3Hg + 3N_2 + 2KCl + 6CO_2;$$

$$3KClO_3 + Sb_2S_3 \rightarrow 3KCl + Sb_2O_3 + 3SO_2.$$

Summing up, we get:

$$3Hg(CNO)_2 + 5KClO_3 + Sb_2S_3 \rightarrow 3Hg + 3N_2 + 5KCl + 6CO_2 + \\ +3SO_3 + Sb_2O_3.$$

It follows from the above equation that the combustion of the shock composition produces both gaseous and solid products. Gaseous products do not have a great harmful effect on the weapon, because they are carried away from the barrel along with the powder gases and their effect is short-lived [86, pp. 15–16].

The greatest impact on the bore of small arms has the effect of solid reaction products. Solid products of antimony oxide and potassium chloride partially in the form of slags settle on the walls of the trunk. The metal of the barrel is fused with the hot slag of the impact composition and becomes fusible. Molten metal particles are carried away by gunpowder gases, in connection with which shells and potholes are formed in the barrel channel, which are formed mainly near the chamber and the bullet entrance. In addition, potassium chloride particles are burnt to the walls of the trunk and due to its hygroscopicity gradually absorb moisture. As a result, potassium chloride is partially dissolved and dissociates into potassium and chlorine ions, which, acting catalytically, causes intense oxidation of iron, and the bore is covered with corrosion products.

Harmful effects are also produced by the combustion of the shock composition of vaporous metallic mercury, which is removed from the firing of the barrel is not completely and partially condensed in the cold part of it in the form of drops. In the barrel channel mercury forms an amalgam, making it difficult for the bullet to pass through the rifling. This leads to leaded bore, which increases over time, and the weapon loses its combat qualities. In addition, mercury amalgamates brass and copper sleeves, causing them to crack.

Combustion products of capsule compositions, in addition to chemical effects, destroy the bore of weapons and purely mechanical way. The combustion of the bore near the chamber is mainly due to the temperature of the capsule slag and a significant rate of departure of these particles into the barrel. As the flame temperature increases, the degree of softening of the barrel metal increases, and thus the introduction of solid particles into it is facilitated, since with an increase in the speed of flight, the particles penetrate deeper into the metal. The greater the content in the impact composition of rattlesnake mercury, the greater its brisance and the rate of decomposition, solid particles with greater force hit the surface of the barrel. There is a "bombardment" of metal, which at a high flame temperature leads to the burning of the trunk and the formation of shells and potholes in it.

Table 2.2.1 — **Formulation of rattlesnake percussion compositions, %**

Primer-igniter	**$Hg(CNO)_2$**	**$KClO_3$**	**Sb_2S_3**
Cartridge 7,62×39R "Nagan"	25	37.5	37.5
Cartridge 7,62×54R	16	55.5	28.5
Cartridges (Germ.) 9×19 Para, 7,92×58	22.5	40	37.5
Cartridge 5,6×16R	50	30	20
Chew	50	30	20

To avoid the harmful effects of combustion products of shock compositions on the barrels of small arms, chemists have proposed a large number of shock compositions that do not have a destructive effect on the metal barrel. Such compositions are called "non-corroding", "anticorrosive" or simply "non-rusting".

Non-corroding compounds began to be actively investigated in the early XX century. Initially, the research was reduced to the replacement of potassium chlorate with another oxidizer that does not contain chlorine. In 1900, it was proposed to replace potassium chlorate with barium nitrate $Ba(NO_3)_2$ with the addition of barium carbonate $BaCO_2$ to neutralize the acidic reaction products. Later, a number of nitro compounds were added to barium nitrate, reducing the content of antimony sulfide in the shock composition and increasing the content of rattlesnake mercury. Of the nitro compounds, picric acid was first used, and then it was successively replaced with TNT, potassium picrate, tetrile, etc.

In addition to barium nitrate, chromic acid salts of various metals (chromates), mainly lead and mercury, were also recommended as oxidants. At the same time, it was suggested that after combustion of the composition, metal oxides, including chromium oxide, will be deposited on the walls of the barrel, forming a protective film that protects it from corrosion. To enhance the Flammability of these compositions added to the lead dioxide, the dioxide of barium and silicon calcium.

As combustible, in addition to antimony sulfide and other substances already mentioned above, lead rhodanide began to be used $Pb(CNS)_2$ and calcium siliceous ($CaSi_2$).

When replacing potassium chlorate with another oxidizer, shock compositions were obtained that did not cause rusting of the weapon, but did not eliminate the mechanical destruction of the metal near the chamber from impacts and the thermal action of solid particles, so when developing non-corroding compositions, mercury began to be replaced by other initiators.

Initially, it was proposed to use instead of rattlesnake mercury rather sensitive to the impact of sulfur nitrogen, but shock compositions with this substance were unsuitable due to its high brisance. The later proposed red phosphorus and picrates also did not spread due to the instability of the former during storage and the weak flammable ability of the latter.

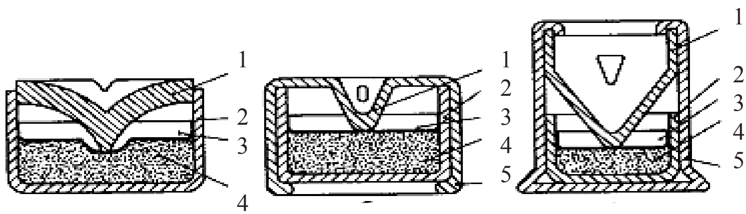
In the future, instead of rattlesnake mercury began to use the main lead salt of trinitroresorcinol and normal, known as TNRS (lead trinitroresorcinate). Subsequent studies have shown that the best are shock compositions containing tetrazene and TNRS.

Tetrazene is a substance that is very sensitive to impact, but it does not have a strong enough flammable ability in relation to the rest of the composition. TNRS is also a good igniter, but its sensitivity to impact is weaker. When mixed, both components have both sufficient sensitivity to shock and reliable Flammability. As an oxidizer, barium nitrate, or nitric acid lead, is added to them, and antimony sulfide or lead rhodanide is added as a fuel.

Table 2.2.2 — **Formulation of some non-rusting percussion compositions**

Components	Content (%)								
Mercury fulminate	35	30	50	40	30	–	–	–	–
TNRS	–	–	–	–	–	40	–	40	40
Tetrazene	–	–	–	–	15	1	3	–	2
Diazodinitrophenol	–	–	–	–	–	4	37	–	–
Barium nitrate	25	35	30	46	–	–	–	35	–
Bertoletov salt	–	–	–	–	25	–	–	–	–
The lead dioxide	35	–	–	–	–	–	–	5	–
Barium carbonate	–	6	–	–	–	–	–	–	–
Tetryl	–	–	–	5	–	–	–	–	–
Antimony sulfide	15	25	20	9	30	–	–	–	–
Glass	–	4	–	–	–	19	19	–	20
The thiocyanate lead	–	–	–	–	–	7	7	–	8
Lead nitrate	–	–	–	–	–	29	34	–	30
Calcium silicide	–	–	–	–	–	–	–	20	–

Currently, two types of primers are used to equip cartridges: without an anvil (open type) (figure 2.2.8) and with its own anvil (closed type) (figure 2.2.9).



a) b) c)

Figure 2.2.9 — **The scheme of caps-igniters with an anvil:**
a — capsule "Boxer"; b — the capsule of Nordenfeld;
c — the capsule "Revelo"; 1 — anvil; 2 — cup; 3 — cover;
4 — the shot composition; 5 — shell

The Berdan igniter capsule (figure 2.2.8) was invented by U. S. army Colonel Hiram Berdan in 1866 and is a metal cap with a shock-igniter composition covered with a foil tin circle. The material of the cap — copper (brass, tombac) with varnished or Nickel-plated or steel with oxide coating. Cartridge cases when using primers of this type are made with a projection of the anvil in the center of the capsule socket and two (one) ignition holes. "Berdan" is the main primer-igniter used in cartridges of Western European manufacturers.

The primer-igniter "boxer" (figure 2.2.9 a) was invented by the English Colonel E. boxer in 1961. It is a metal cap with a shock-igniting composition and an anvil in the form of a two- or three-petalled cone. Primers of this type are used in sleeves with a single ignition hole in the center of the capsule socket to facilitate the re-discharge of cartridges, are the main primers in the United States.

The "Gevelo "primer (figure 2.2.9 b) was originally used in the Pot-Schneider hunting cartridge (France) in 1861In its modern form it was released at the end of the XIX century by a French firm Gevelot. The primer-igniter has a brass shell (body) in the form of a sleeve with a protruding flange, at the bottom of which a primer-igniter of the Berdan type is placed, containing a shock-igniting composition, is held by an anvil inserted into the sleeve. The anvil is located on the shoulder pads available in the sleeve and is kept from falling out by the rolled edges of the sleeve.

Russian industry produces the following types of primers: "Zhevelo-M" — gremuchertutny; "Zhevelo-M" — powerful, "Zhevelo-N" (NG) — non-rusting (GOST 24579-81); KVM-3 (KVM-3M) — military.

Primer-igniter "Winchester" appeared in the 70s of the XX century. and in a short period of time became one of the main. Outwardly resembles a primer-igniter "Zhevelo", but has differences: the body (sleeve) is open from the bottom part, where a small primer-igniter with an anvil is placed with the help of a press fit, the ignition hole of a smaller diameter is usually sealed with varnish. Thanks to the new design, the inertial stability is increased, which protects against accidental actuation, the probability of anvil departure is eliminated and the calibration of the fire beam is provided when passing the ignition hole of the normalized constant cross-section. Winchester primers are manufactured in the Russian Federation under the name KV-21 for sleeves with a seat diameter of 5.6 mm and KV-22 (KV-209) for sleeves of the European standard with a seat diameter of 6.2 mm.

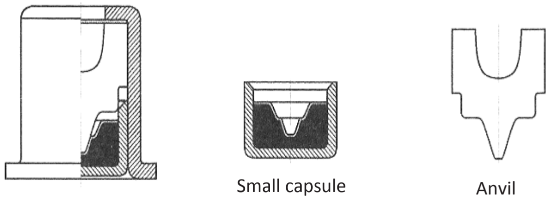
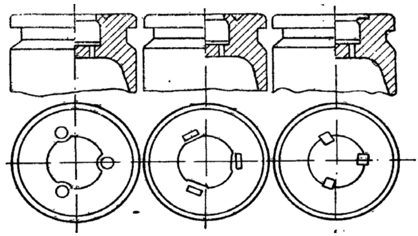
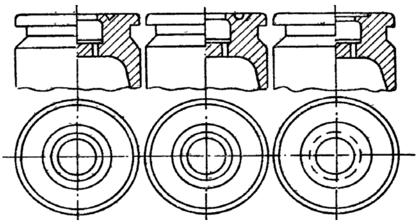


Figure 2.2.10 — **The system of the primer-igniter KV-21**



a



b

Figure 2.2.11 — **Attachment of the primer-igniter in the cartridge case:**
a — core in three points; b — core around the circumference of the capsule socket

Fastening of the primer-igniter in the capsule socket of the sleeve is carried out, as a rule, by the method of tight fit (with tension), core at three points and around the circumference of the capsule socket. This provides the possibility of trouble-free operation of cartridges (ammunition) in self-loading and automatic manual small arms (figure 2.2.11).

The design of electric primers contains elements that convert electrical energy into heat. Currently, cartridges (ammunition) are used electric primers-igniters of two types.

The first type includes bridge caps-igniters (electric incandescent igniters). The design of these devices includes an incandescent bridge (made of nichrome, platinum-iridium or Melchior wire having a high resistivity) immersed in the initiating mixture of substances. When applying an electric current of a certain magnitude, the metal thread, heating to the required temperature, causes ignition of the initiating composition (electric igniters EVN-01M1, EKM-1A/80 and EKM-1A/190) used in cartridges (ammunition) of traumatic weapons of caliber 18×45T and 18×55T [298]. As the initiating composition of electric igniters with "incandescent bridge" at the enterprises of the Russian Federation, the following composition is used: potassium chlorate (49.5 %), lead rhodanide (49.5 %) and lead plumb (1 %) [28, p. 139]. It is also possible to use a different formulation of compositions, for example: lead rhodanide (40–60 %), potassium perchlorate (35–55 %), lead chromate (7–30 %), polymer binder (0.1–2 over 100 %) [299].

The second type of electric primers-igniters-electric igniters with conductive composition (conductive additives-coal, powdered metals are introduced into the mixture of the initiating composition). The passage of an electric current through the mixture causes local heating of the mixture of the initiating composition and its ignition. This type of electric igniters is used in the designs of caseless cartridges (ammunition) 4.7×33 to the G11 assault rifle of Heckler & Koch and 5.7×27 UCC to the vec-91 hunting rifle of Voere [56, pp. 205–208]. In cartridges (ammunition) 18×45T and 18×55T to traumatic weapons are mainly used electric igniters with "incandescent bridge" (EVN-01M1, EKM-1A/80 and EKM-1A/190). Compared with percussion-type primers, electric igniters have such an undeniable advantage as speed [22, pp. 29–30].

In addition, compared with percussion-type primers, electric igniters have such an undeniable advantage as speed. This is confirmed by the data of the comparative table below, which reflects the ratio of the time of speed of the weapon with manual firing control when using percussion and electric ignition primers in cartridges (ammunition), as well as various types of triggers. The delay time in the "man — weapon" system begins from the moment the shooter makes a decision on the production of the shot and ends with the moment of departure of the projectile from the barrel channel. This parameter is defined by the formula:

$$t_{\text{delay time}} = t_1 + t_2 + t_3 + t_4,$$

where t_1 — the reaction delay time;
t_2 — the response time of the trigger;
t_3 — the time of operation of the shock mechanism;

t_4 — the time from the beginning of ignition of the propellant charge until the departure of the projectile from the bore [22, pp. 29–30].

Table 2.2.3 — **The ratio of the time delay of the shot depending on the type of ignition of the propellant charge** [22, pp. 29–30]

Type of the trigger	The lag time of the shot. $t_{зап}$. sec	Component of the time delay. sec			
		t_1	t_2	t_3	t_4
Mechanical	0.19…0.30	0.04…0.06	0.11…0.18	0.006…0.01	0.030…0.045
Electromechanical	0.17…0.29	0.04…0.06	0.09…0.17	0.006…0.01	0.030…0.045
Electric	0.08…0.11	0.04…0.06	0.005…0.006	–	0.030…0.045

Thus, the analysis of the data given in table 2.2.3 allows to draw the following conclusions about the advantages of electric ignition:

1) this type of ignition is the most rapid-acting type of initiation of the propellant charge, capable of providing maximum speed of use of weapons;

2) the absence of mechanically connected parts in the electric ignition system and the ability to regulate the trigger force within a wide range allow to reduce the fluctuations of the weapon at the time of manufacturing, aiming and firing, thereby increasing the probability of hitting the target.

Application of electric igniters in cartridges of the traumatic weapon of caliber 18×45T and 18×55T contributed to a significant increase in the reliability and efficiency of the complex "weapon — cartridge". It is noted that the introduction of microprocessor control of electric igniters cartridges virtually eliminated the possibility of delay in firing, and the replacement of the cartridge in the design of the gunpowder charge increased linkage of the initiating composition had a positive impact on the stability of the striking properties of the throwing element. The spread of bullet velocity when firing these cartridges was ±10 m/s [262], it was unattainable when used as a propellant charge pyroxylic gunpowder.

The use of the design of cartridges (ammunition) small firearms of the electric igniter makes it impossible to identify a specific instance of small firearms in the classical sense (on the trail of a striker on the percussion cap of the igniter). However, the use of forensic and ballistic tests of cartridges (ammunition) 18×45T and 18×55T to the traumatic weapon shows that the solution to this problem is possible by researching the marks on the case and the base of the cartridge formed by locking the cartridges when loading (or unloading) as well as traces of contact groups gun [112, pp. 320–329].

Schemes of the internal device of the main types of electric igniters (EVN-01 M 1, KM-1A/80 and KM-1A/190) are presented in the figure 2.2.12. The difference between the electric igniter EVN-01M1 from the other two mentioned is that in their design, instead of a powder charge, an increased hitch of the initiating composition is used, which, burning more intensively than gunpowder, allows you to create the necessary discharge pressure in the cartridge case, informing the thrown element the necessary kinetic energy (80 J). The impossibility of obtaining stable ballistic characteristics of the cartridge 18×45T is explained by the fact that in a barreled traumatic firearm, the projectile receives acceleration and directional movement on the section of the cartridge case (ammunition) with a length of about two calibers (figure 2.2.12 b), as a result of which it becomes impossible to provide a stable value of the combustion rate of the propellant charge and achieve the necessary pressure in the discharge space [112, pp. 320–329; 113; 114; 298].

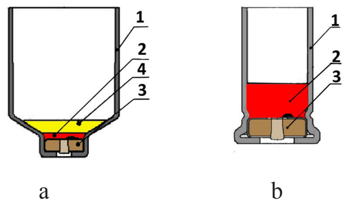


Figure 2.2.12 — **The system of the electric igniter cartridges to the traumatic weapon:** a — EVN-01 M 1; b — KM-1A/80 (KM-1A/190); 1 — body, 2 — the triggering composition, 3 — washer with filament bridge, 4 — propellant charge [298]

The refusal to use the powder propellant charge in the design of the cartridge (munition) under consideration and the use of the pyrotechnic composition of the electric igniter as an energy source allowed to eliminate this drawback. The burning pyrotechnic composition exceeds the burning rate of pyroxylic gunpowder several times, which made it possible to achieve the necessary level of gas pressure on the projectile in a relatively short section of the shell casing cartridge (ammunition), which performs the function of the barrel in it. The kinetic energy of the projectile element (bullet) of such a cartridge is sufficient to defeat the target and is 80–90 J.

A similar principle is used in Flaubert cartridges, in which the propellant charge is absent, and its functions are performed by the impact pyrotechnic composition [113; 114] (figure 2.2.13).

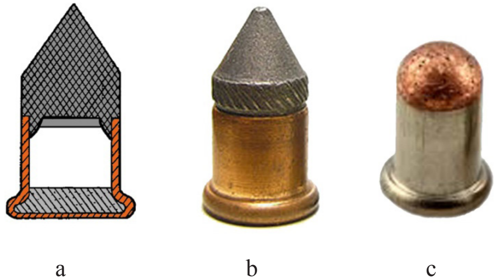


Figure 2.2.13 — **Device doorsteps of Flaubert's cartridges of caliber of 5,6 mm (.22 Cap) and 4 mm:** a — the internal structure of the cartridge, b — cartridges Flaubert caliber 5.6 mm (.22 Cap), c — 4 mm Flaubert cartridges

As it was noted above, earlier operating Technique of criminalistic research of cartridges (2008) did not allow to carry a cartridge of Flaubert to category "ammunition" as the propellant powder charge in a design of this cartridge is absent, and its functions are carried out by shock pyrotechnic structure [163]. At the same time practice of expert research of such objects testifies that the power characteristic of the thrown element of such cartridges can exceed the threshold of the minimum specific kinetic energy of the thrown element established in forensic ballistics (0,5 J/mm^2) even at factory value of a hinge of pyrotechnic structure in a sleeve; in addition, these cartridges are easily subjected to overvoltage homemade way, which allows you to significantly increase the damaging properties of the throwing element [114; 305]. Thus, we can agree with the position of S. V. Yatsenko, who believes that the absence of a propellant charge (as an energy source) in the design of cartridges is not the basis for their exclusion from the category of ammunition [303, p. 168]. We believe that in this case, the determining criterion for assigning such a cartridge to the category of ammunition will be sufficient to defeat the target value of the kinetic energy of the thrown element [129; 137; 142].

Propellant charge. As a propellant charge in the cartridges (ammunition) of hand-held small arms, both smoothbore and rifled, smokeless gunpowder is currently used. (Smoky gunpowder is used in isolated cases in cartridges of homemade equipment for hunting smoothbore hand-held firearms, signal cartridges). Gunpowder as an energy source has been used in hand held small arms since its inception. The main advantage of smokeless powder is relatively easy ignition of burning in parallel layers, which allows you to control the shooting process [55, pp. 264–271]. Currently, many types of gunpowder are known, but many of them do not meet the requirements, which is why practical application in the design of cartridges (ammunition) has not been found.

One of the main ballistic requirements on propellants are making the shot given the speed of the throwing element when installed technical specifications level maximum pressure in the barrel of a small firearm, and to ensure permissible deviation parameters initial velocities of methane element from the average value. In accordance with GOST 23128-78 “hunting Cartridges for rifled weapons” the average deviation of the bullet velocity in cartridges (ammunition) of factory manufacture from the average values when fired is set to no more than 15 m/s [7; 201, p. 5].

In cartridges (ammunition) used for shooting from hand-held small arms, pyroxylic gunpowder on a volatile solvent and lacquer gunpowder made of nitrocellulose varnish are used. Improvement of gunpowder is reduced to obtaining the most favorable ballistic characteristics by changing the methods of production of gunpowder, the introduction of various additives that improve both ballistic and operational properties. Depending on the number of high-energy components included in the powder, there are: a) single-base (without high-energy additives); b) dibasic (with the addition of one substance) and c) tribasic gunpowder (with the addition of two substances) [34, pp. 506–508; 54, pp. 264–271; 250, pp. 121–128; 264, pp. 189–196]. As high-energy additives used nitroglycerin, diethylene glycol dinitrate, hexogen, octogen [54, pp. 264–271; 291, pp. 273–275]. Experts point out that the cartridges of hand-held small arms are used mainly one-and two-basic types of gunpowder, while it is allowed to mix several types of gunpowder to obtain the necessary ballistic characteristics of cartridges (ammunition) [54, pp. 264–271].

Pyroxylin dibasic gunpowder, used to equip cartridges for smoothbore hand-held small arms, is a powder based on pyroxylin with the addition of nitroglycerin. Such gunpowder provides a higher temperature stability of the ballistic characteristics of the shot compared to single-base gunpowder due to the higher Flammability of nitroglycerin. To the greatest extent the advantages of dibasic powders are manifested in low temperature conditions.

Depending on the production technology, powder elements can have a plate, granular or cylindrical shape.

Plate powder elements are thin plates of round, square or diamond shape. Diameter or side plates for most gunpowder — 1.0–2.5 mm; thickness — 0.15–0.40 mm.

Granular powder elements are granules of different shapes and different fractional composition. Gunpowder in the form of granules spherical or close to spherical shape is called spherical gunpowder.

Cylindrical powder elements are cylinders or cylinders with a Central channel. The diameter of the cylinder for the majority of powders is 0.5–1.0 mm, length 1-5 mm; the diameter of the Central channel is 0.1–0.2 mm.

The greatest distribution for equipment of cartridges for shotguns got single base powders with plate-like shape of the powder elements due to the low cost of their production. The shape and size of the powder elements are optimized for the conditions of combustion of the propellant charge in cartridges for smoothbore hand held small arms. At the same time, all monobasic gunpowder contain 96–98 % pyroxylin and have almost the same chemical composition. The chemical composition of dibasic powders of different manufacturers also has no significant differences. Therefore, the difference in the characteristics of gunpowder is not related to their chemical composition.

The main differences in the characteristics of gunpowder associated with the density of gunpowder. Production technologies allow to produce gunpowder with a density of approximately 300 to 1000 g/dm^3. In turn, the density of gunpowder is determined by its porosity. The porosity of the powder elements, i. e., the presence in the powder elements of microscopic voids that increase the surface and rate of combustion, identifies all the main ballistic characteristics. Thus, the powder with high porosity and correspondingly low density has a high burning rate (quickmatch gunpowder), and gunpowder with a low porosity and a correspondingly high density has a low burning rate (melanogenesis gunpowder).

An important characteristic of gunpowder along with the density is its bulk density, which characterizes the mass of gunpowder in a fixed volume. The bulk density of gunpowder is determined by the density of the gunpowder, as well as the size and shape of the powder particles. Thus, depending on the bulk density of gunpowder with the same mass can occupy a different volume in the cartridge case.

Gunpowder of different brands with the same form of gunpowder elements have no visible differences, but many manufacturers tinted gunpowder for visual identification of the brand of gunpowder.

To give the powder the required flowability and eliminate the tendency to electrification, sticking of powder elements and sticking of powder elements on the components and parts of the equipment, the powder can be subjected to graphitization. Gunpowder elements of graphite gunpowder acquire a gray color.

When choosing gunpowder, the following regularities are taken into account:

the characteristics of gunpowder for ammunition of a specific caliber is determined by the mass of the methane equipment. Reducing the mass of the equipment thrown requires the use of gunpowder with a higher combustion rate burning;

the characteristics of gunpowder for cartridges of different calibers are determined by the size of the caliber. Reducing the caliber and the associated reduction in the volume occupied by the gunpowder requires the use of gunpowder at a lower rate of burning.

From the specified conclusion follows about impossibility of use of one brand of gunpowder for equipment of cartridges (ammunition) of various caliber, with various weight of the thrown equipment.

Hunting smokeless gunpowder "Sokol", intended for use in cartridges (ammunition) for smoothbore hunting and sports hand-held firearms, is produced for a long time and is a single-base plate gunpowder with high density and low speed burning. This gunpowder is a universal gunpowder with compromise properties and provides acceptable ballistic characteristics of cartridges of 12, 16 and 20 calibers when using a variety of auxiliary elements of equipment, including cardboard, felt, wood-fiber and polymer wads and gaskets. Moreover, under designing gunpowder "Sokol" one of tasks was ensuring security patrons, kitted out hunters in household conditions, including low sensitivity shot being fired to excess masses gunpowder. Note that this gunpowder does not meet modern requirements and does not provide the necessary functional characteristics of cartridges, so it is practically not used in industrial equipment.

For each brand of gunpowder manufacturers provide recommendations on the choice of the mass of gunpowder when used in cartridges of different calibers, with different weight of the thrown equipment, and in some cases for different types of thrown equipment (lead shot, steel shot, bullet, etc.). To the greatest extent gunpowder adapted for use in cartridges for smoothbore hunting hand-held firearms caliber 12/70. All manufacturers offer brands of gunpowder intended for equipment of the most popular hunting and sports cartridges of caliber 12/70 with weight of lead shot of 24, 28, 32 and 34–36 g.

The results of ballistic tests of cartridges can be chosen powder with optimum characteristics for equipment of cartridges of other calibers, with different mass and other types of throwing equipment.

The approximate ratio between the mass of the propellant charge of gunpowder brand "Sokol" and the mass of lead shot for hunting cartridges of different calibers with a sleeve length of 70 mm are given in the table 2.2.4.

Table 2.2.4 — **Table of the ratio of the mass of shot and gunpowder at independent equipment**

Caliber and weight of the gun, kg	The type of wad	The charge of gunpowder "Sokol" at a temperature of		Projectile fractions, g
		+ 20 °C	– 20 °C	
12 3.2–3.5	W F C	2.3 2.2 2.0	– 2.3 –	32–36
12 2.8–3.1	W F C	2.2 2.1 1.9	– 2.2 –	30–32
16 3.0–3.2	W F C	2.1 2.0 1.8	– 2.1 –	30–32
16 2.7–2.9	W F C	1.9 1.8 1.6	– 1.9 –	27–29
20 2.6–3.1	W F C	1.7 1.6 1.4	– 1.7 –	26–31
20 2.4–2.5	W F C	1.6 1.5 1.3	– 1.6 –	24–26

Note. Wads: W — wood-fiber, F — felt osalenny, C — polyethylene container.

For dibasic gunpowder the ratio between the density of gunpowder and the mass of the thrown equipment may be different.

An important requirement for gunpowder, determining their suitability for practical use, is sufficient resistance, i. e. the ability for a long time to maintain unchanged their physical and chemical, and therefore ballistic properties. The analysis of works on operation of cartridges (ammunition) to fighting (military) rifled manual small arms testifies that term of the safe (without change of physical and chemical properties) the smoke-free gunpowder stabilized with diphenylamine over 20 years, unstabilized — 10 years; the useful life of gunpowder in cartridges (ammunition) outside the factory capping is one and a half to two times less due to the loss of their ballistic properties due to adverse storage and operation conditions. In military science the guaranteed period of storage of cartridges (ammunition) is considered to be 40 years as on expiry of such period occurs degradation of the propellant charge cartridge (ammunition), resulting in increases the speed of throwing item, and the gas pressure [7; 83, pp. 23–24].

Experimental shooting of cartridges (ammunition) 7,92×58 of factory manufacture (1936–1939 of manufacture), carried out in 2002 by D. A. Burya, showed that under elementary storage conditions, the change in the speed of the thrown element from the normative established by the technical documentation was 1–5 m/s. On the basis of the results of this experiment, the scientist made a reasonable conclusion that the striking ability of the projectile element of the cartridge (ammunition) of factory manufacture, due to the presence of stabilizers in the powder charge, provides stable ballistic qualities and the necessary level of striking ability even with significant shelf life [31, pp. 53–55].

In forensic ballistic examination of cartridges (ammunition), handheld small arms, barrel gas weapons, traumatic weapons combustion products of propellant and capsule composition are involved in the formation of additional traces of the shot, allowing to determine the firing distance, as well as with a certain probability to determine the person who fired the shot. This issue is fully covered in the special forensic literature [43; 153; 167].

At the same time it is important to pay attention that according to provisions of earlier operating Technique of criminalistic research of cartridges [163] research of physical and chemical properties of gunpowder in the course of forensic ballistic research of cartridges (ammunition) of manual small arms is not included in competence of the expert ballista, its actual existence as a design element is stated only.

Throwing element. According to paragraph 473 of GOST USSR 28653-90 "small Arms. Terms and Definitions" a Throwable element is understood to be "a part of a small arms cartridge intended to hit targets... that is thrown when fired from a barrel bore" [190]. From this definition it follows that the element of the design of the cartridge (ammunition), providing its main purpose — the direct defeat of the target, is the throwing element.

The movement of the bullet on the trajectory is considered as the movement of the body of rotation in the flow of gas or liquid.

The main ballistic characteristics of the bullet are: weight, manufacturing accuracy; ballistic properties, aerodynamic properties, stabilization, striking properties.

As a result of the development of science and technology by the 1970s, the shape, size, weight and design features of bullets used in cartridges (ammunition) of rifled small-arms firearms were developed and theoretically substantiated. To this time were implemented amp; d patrons (ammunition) with metaemym element of reduced caliber 5.56 mm — in countries NATO and caliber 5.45 mm — in the USSR [56, pp. 90–126; 57, pp. 692–708; 58, p. 5]. A certain technical limit was reached in the field of creating samples of hand-held small arms, since the developed samples of hand-held small arms had all the necessary tactical and technical characteristics. However, the cartridges (ammunition) used for firing in these samples did not fully meet the requirements.

Since the 1970s, the main directions of improvement of the projectile element of cartridges (ammunition) of hand-held small firearms have been reduced to the following: 1) improvement of ballistic properties of the thrown element on the trajectory; 2) development of bullets with the necessary damaging effect; 3) development of projectile elements of cartridges (ammunition) for use in certain conditions (under water, with subsonic bullet speed, on Board aircraft, etc.).

The mass of the bullet is determined by a combination of shaped and dimensional characteristics, as well as the properties of the materials used to manufacture its elements. The most important is the relationship between the mass of the bullet and its outer diameter. Depending on the outer diameter used in cartridges (ammunition) bullets are divided into:

caliber — with an outer diameter equal to or close to the diameter of the bore (caliber bullets). The peculiarity of this type of bullets is the ability to achieve a high mass;

subcaliber — bullets with an outer diameter substantially smaller than the bore diameter. Designed to be placed in a container that can be integral or composite. The composite container is an annular element (pallet) and located between the outer surface of the bullet and the inner surface of the sleeve of individual sectors (segments). After departure from the bore elements of the composite container are separated from the bullet under the influence of the incoming air flow. The peculiarity of sub caliber bullets is the ability to achieve a low mass of the bullet and a higher flight speed on the trajectory.

The mass of the bullet and the initial velocity of the bullet should be considered as two interrelated and at the same time contradictory characteristics of the bullet cartridge. Reducing the mass of the bullet provides the ability to increase the initial velocity of the bullet and Vice versa. To achieve the maximum initial kinetic energy of the bullet requires a decrease in mass and an increase in initial velocity. However, the achievement of maximum initial kinetic energy does not guarantee the achievement of maximum kinetic energy at a given firing range, since the ballistic properties of the thrown element depend on its mass, diameter and speed, and aerodynamic properties depend on the shape and speed.

Maximum firing range describes the maximum range at which an effective defeat of the target is possible. The maximum range is determined by the mass of the bullet and its initial velocity, size, ballistic and aerodynamic properties. The greatest impact on the maximum range of fire has a bullet mass. Light bullets of small calibers are characterized by a short range. In this case, the maximum firing range is limited not only by the value of the kinetic energy of the bullet on the trajectory, but also by the lowering of the trajectory.

High accuracy of bullet manufacturing is a necessary condition for straightness of bullet trajectory and high shooting accuracy.

The accuracy of manufacturing a bullet, considered as a body of rotation, is characterized by the eccentricity of the center of mass, i. e. the distance between the center of mass of the bullet (the point of application of gravity) and the longitudinal axis of the bullet. Ideally, the eccentricity of the center of mass is located on the longitudinal axis of the bullet (center of mass is zero). In the real case, the eccentricity of the center of mass is always greater than zero, with the result that the forces acting on the bullet on the trajectory are systematically applied to the bullet not symmetrically with the corresponding curvature of the trajectory. This is largely characteristic of three-element (surrogate) steel-core bullets to rifled hand-held small-arms firearms. The processes that occur with such bullets at the time of firing will be described in detail in section 3.4 of Chapter 3.

The accuracy of the bullet is determined solely by the manufacturing technology. Improving the accuracy of the bullet requires the use of a number of technological techniques. In cartridges (ammunition) for smoothbore hunting hand-held small arms, pores and voids in the body of a lead bullet arising in the casting process can cause a significant eccentricity of the center of mass and, as a consequence, unstable ballistic characteristics. To reduce the influence of this factor in the manufacture of such bullets in the industry, as a rule, injection molding is used.

One of the main ways to reduce the influence of the eccentricity of the center of mass of the bullet on the straightness of the trajectory is the unwinding of the bullet relative to the longitudinal axis as a result of interaction with the rifling of the barrel-stabilization by rotation (characteristic of rifled weapons) or the incoming flow of air or liquid-turning bullets (hunting smoothbore and smoothbore underwater hand-held firearms). At each revolution of the turning bullet there is a partial compensation of influence of eccentricity of the center of masses of a bullet which periodically appears directed in different parties from a longitudinal axis of a bullet. Turning bullets to hand-held small arms with a smooth bore in motion is provided by the presence of structural elements made at an angle to its longitudinal axis.

A significant influence on the ballistic properties of the bullet has the coefficient of aerodynamic force (coefficient of drag), directed along the longitudinal axis of the bullet, which depends in a complex way on the shape and speed of the bullet. Advantageous aerodynamic shape have a bullet with a conical, oval or hemispherical head; the least advantageous aerodynamic shape have a bullet with a flat head (typical for pistol bullets and some bullets to smoothbore hunting hand-held firearms).

Empirically found that the best ballistic properties have bullets with the largest mass at the smallest diameter. At the same time, bullets with a large elongation (swept bullets) have the greatest mass at the smallest diameter.

An important practical value is a significant increase in the coefficient of aerodynamic force at a bullet speed close to the speed of sound (about 340 m/s in the air under normal conditions). In this regard, in practice, the parameters of the bullet and the characteristics of the shot are selected in such a way that the bullet speed at the maximum firing range is higher or lower than the speed of sound (for hand-held small arms equipped with a sound suppression device).

Stabilization of the bullet is a prerequisite for the straightness of the trajectory of the bullet and high accuracy.

The ability of the bullet, considered as a body of rotation, to stabilize on the trajectory means the ability of the bullet to maintain the coincidence of the velocity vector with the longitudinal axis of the bullet under the influence of destabilizing factors. There are three main ways to stabilize the flight of a bullet on the trajectory: due to the shape of the bullet; due to the high-speed axisymmetric rotation of the bullet; due to the location of the center of pressure behind the center of mass of the bullet.

Stabilization due to the shape of the bullet is provided for bullets of stable ballistic shape. The stable ballistic shape of a bullet is a sphere. Using bullets of the spherical form is the most simple and effective way to stabilize the bullet trajectory. This effect has previously been used in muzzle-loading smoothbore handgun firearms, but due to the worldwide transition of the world's armies to rifled bore weapons, the use of such bullets is currently limited to use in smoothbore hunting handgun firearms. Bullets of this kind are prone to ricochets and are prohibited during collective hunts.

Stabilization of the bullet due to high speed axisymmetric rotation and the resulting gyroscopic effect is used in rifled weapons. In smoothbore weapons with this purpose may be used the barrel with the threaded end of the land or a special attachment with the rifling "paradox".

For shooting from a barrel with a rifled section or shooting with a nozzle "paradox" bullets of a special design are required that is caused by unfavorable conditions of interaction of a bullet body with rifling. In rifled weapons, the bullet begins to interact with rifling in the initial period of the shot, when the speed of the bullet is negligible, and acquires the necessary speed gradually, as the speed increases when moving along the barrel channel. When firing from a barrel with a rifled end section or when firing with a paradox nozzle, the bullet begins to interact with the rifling after reaching a high speed. In many cases, not intended for this bullet when interacting with rifling does not acquire the necessary axisymmetric rotation, and deformed and pushed through the rifled section of the barrel (there is a "breakdown with rifling"). The results of shooting such a deformed and unstabilized bullet significantly deteriorate.

In addition, it should be borne in mind that the frequency of axisymmetric rotation of the bullet, necessary for the occurrence of the gyroscopic effect, should be, depending on the caliber of several tens of thousands to several hundred thousand revolutions per minute. Such high rotational speeds cannot be achieved by unwinding the bullet by the incoming air flow in a smoothbore hunting hand held small arms firearm.

Stabilization bullets expense of location center pressure behind center masses bullets and emerging stabilizing moment aerodynamic forces relatively center masses is used in most bullets for hunting bullet patrons. A necessary condition for stabilization of the bullet is the location of the center of pressure of the bullet (the conditional point of application of the resultant aerodynamic forces acting on the bullet in flight) behind the center of mass. Stabilization bullets the specified way needs provide expense of design bullets by adherence to one any or simultaneously two conditions: center masses bullets should be shifted to parent parts of bullets; center pressure bullets should be shifted to tail parts of bullets.

The greater the distance between the center of mass and the center of pressure (shoulder stabilizing moment), the higher the efficiency of stabilization of the bullet. To shift the center of mass to the head of the bullet, the main part of bullets to smoothbore hunting hand-held firearms contains a heavy (for example, lead) head part and a light (for example, polymer) tail part. For maximum displacement of the center of pressure to the tail of the bullet can be equipped with a tail, which increases the stabilization due to the location of the center of pressure of the bullet behind the center of mass of the bullet.

The development of new types of designs of bullets used in the design of cartridges (ammunition), previously adopted, allowed to significantly change the properties of the complex "weapon — cartridge" as a whole, as well as to solve highly specialized problems. V. A. Ruchkin on this occasion notes that the constantly emerging need to solve narrow-purpose tasks inevitably leads to the specialization of small arms and ammunition used in it and, as a consequence, to the creation of fundamentally new models of small arms; it is possible to upgrade only ammunition with the same standard sample of weapons [228, p. 219–221].

The validity of this statement is clearly confirmed by the nomenclature of cartridges (ammunition) developed and used for shooting from a Makarov pistol (hereinafter-Mak) (figure 2.2.14).

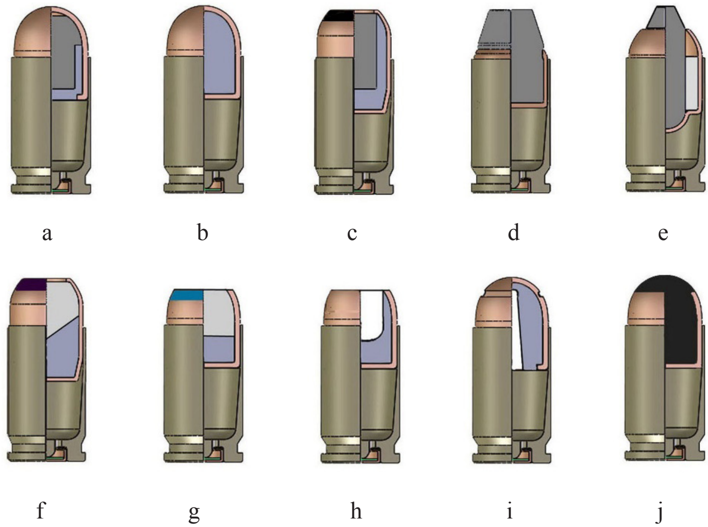


Figure 2.2.14 — **Pistol cartridges 9x18 Mak, used for shooting from a Makarov pistol:** a — 9-mm pistol cartridge (57-N-181S) with steel core bullet; b — 9-mm pistol cartridge (57-N-181) with lead core bullet; c — 9-mm pistol cartridge with bullet increased penetration action RG 028; d — 9-mm pistol cartridge with bullet increased penetration (7H15); e — 9-mm pistol cartridge (7N25) with armor-piercing bullet PBM; f — 9-mm pistol cartridge increased stopping action (SP-7); g — 9-mm pistol cartridge with bullet reduced penetration capacity (SP-8); h — 9-mm pistol cartridge with expansive bullet (PE); i — 9-mm pistol cartridge with a bullet ricochet reduced ability (PRS); j — 9-mm pistol cartridge with combined semi-shell rubber bullet of limited striking capacity

Bullets to rifled manual small arms firearms are divided into four main groups: single-element (bezobolochechnye); two-element (shell and semi-shell); three-element (shell); multi-element (special).

Single-element design have, in particular, bullets cartridges 5,6×16R, 5,6×10R, 7,62×39R, used for shooting sports and hunting rifled hand-held firearms. As a rule, they are made of lead and its alloys with antimony. However, lead does not provide a hard grip on the rifling of the barrel, which is the main drawback of such bullets. Under raising pressure gases in canal trunk is happening “disruption with rifling” that makes impossible the use of such patrons in combat manual small arms firearms in view restrictions primary speed and range called the shots. In addition, the use of lead complicates the action of automation of self-loading hand-held small firearms due to its partial evaporation and settling on the details of the exhaust mechanism.

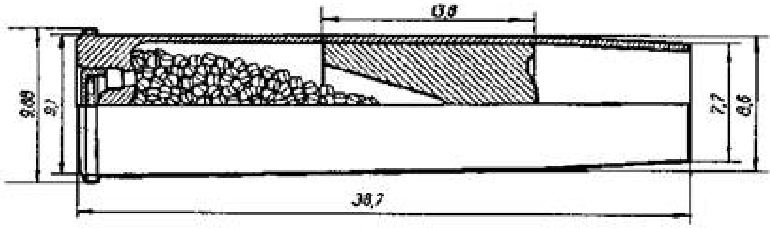


Figure 2.2.15 — **Device and dimensional characteristics of the 7.62×39R sports cartridge for the revolver “Nagan”**

The use of single-element bullets is currently limited because the lead used in their manufacture does not have the necessary characteristics. Exception comprise tselnotochenye bullets from copper alloys (bronze), designed to called the shots from sniper and hunting firearms (as rifled, so and smoothbore in as a subcaliber), the use of their in automatic weapons is limited to high labor intensity assemble and value of (figure 2.2.16).

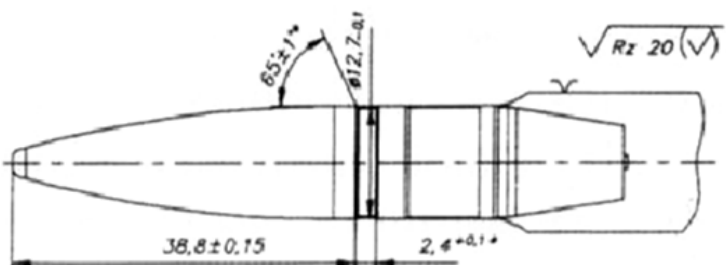


Figure 2.2.16 — **All-metal copper alloy bullet to sniper cartridge 12,7×114**

For shell (two-element) bullets, such a disadvantage as a breakdown from the rifling is not characteristic. In such bullets, the lead core is placed in a shell of brass, Nickel silver or bimetal, which ensures easy forcing of the bullet when entering the rifled part of the barrel bore in the initial period of the shot and the absence of failures with rifling.

Melchior (an alloy containing 80 % copper and 20 % Nickel) is considered to be the best material for making bullet shells for rifled hand-held small arms, but cheaper materials are currently used. For the manufacture of cartridges (ammunition) in the Russian Federation used bimetal-3 (steel 11KP, clad tompak L90). Tompak layer (alloy 90 % copper and 10 % zinc) covers the steel on both sides, its thickness is 4–6 % of the thickness of the steel [90].

Design of jacketed hollow-point bullets suggests the presence of an unclosed contour of the tip of the bullet shell. These bullets are expansive (deformable) bullets. At a meeting with the target due to deformation of the lead vertex, pressure is created, deforming the bullet in radial directions, significantly increasing its cross-section and, accordingly, the kinetic energy transmitted to the target. In addition, in order to enhance the damaging effect, the shell structure may have longitudinal external or internal incisions (figure 2.2.17).

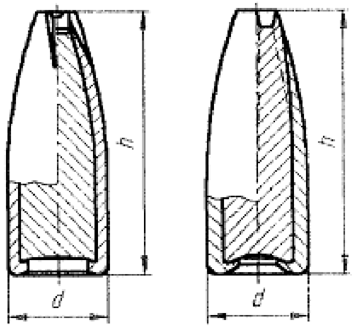


Figure 2.2.17 — **System expansive bullets with longitudinal cuts shell**

This type of bullets is used in hunting rifled hand-held firearms caliber 5.45–9.5 mm when hunting medium and large animals, as well as pistol cartridges (ammunition) used by law enforcement agencies. Their use in combat (military) hand-held small arms is prohibited by international treaties.

Expansive bullets are divided into three main types: with limited expansiveness; without limitation of expansiveness; fragmented.

Bullets with limited expansiveness consist of a tompak shell divided into two parts: a weakened head and a strengthened head. When the target is hit, the head part expands, transferring kinetic energy to the target, while the tail part provides a greater depth of penetration. Another option is possible, when the function of weakening the head part is performed by a cavity in the lead core (figure 2.2.18).

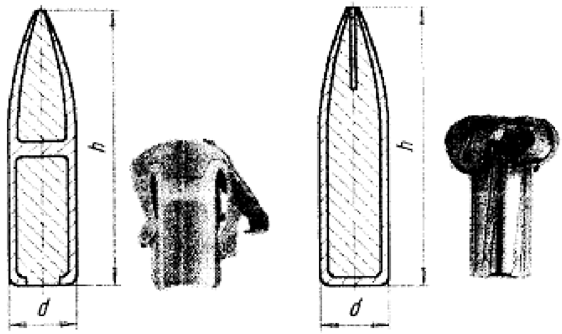


Figure 2.2.18 — **System expansive bullets with limited expansiveness**

Bullets without the limitation of expansiveness, as a rule, have a bare top in the head and a weakened shell structure in the form of longitudinal external or internal incisions (figure 2.2.17).

In fragmented (divided into separate fragments) bullets, in addition to the weakened shell structure, a core consisting of several sectors is usually provided, or cuts on the shell and cores to ensure the formation of separate striking elements at the time of hitting the target. For reliable action expansive bullets its kinetic energy at the time of destruction should be about 200 J.

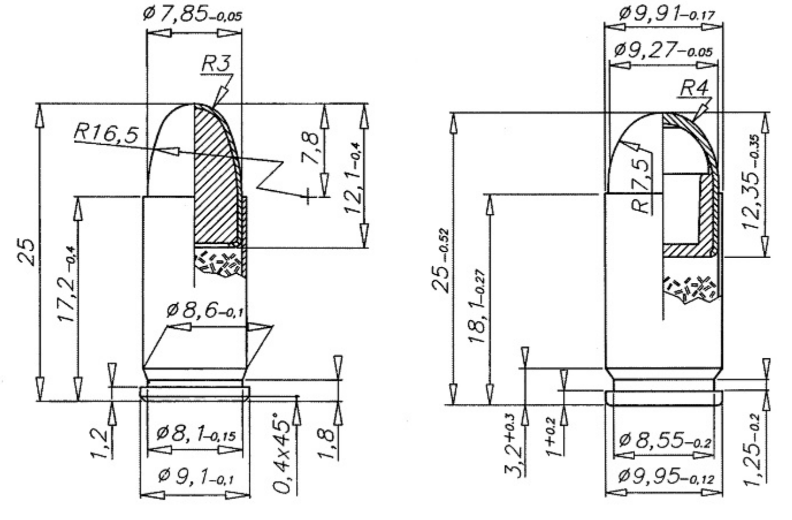
Pistol cartridges (ammunition) of 9×19 with expansive bullets possessing the increased striking action now received wide distribution. As examples of expansive bullets to smoothbore hunting manual small arms firearms can be called bullets Shirinsky-Shikhmatov, Polev-3, Polev-6, Hexolit32, as well as homemade explosive bullets inserted into the expansive cavity primer-igniter "Zhevelo" and a charge of gunpowder.

In modern cartridges (ammunition), two- (figure 2.2.19 a) and three-element bullets (figure 2.2.19 b) are used to combat rifled handheld small firearms. The use of three element bullets with steel cores in service and civilian weapons is prohibited by regulatory legal acts.

In bullets of three-element design the part of lead is replaced by a core from steel. This allows you to reduce the cost of production and provide a punchy action (previously, such bullets were called surrogate). In addition, increased action on the target can be provided by partial exposure of the hardened steel core protruding from the shell of the bullet. In General, such bullets consist of a core (steel, ceramic, polymer), a shell (element (part) of the bullet cartridge, designed to accommodate all its components and giving the bullet the necessary external shape) and a shirt (bullet element, which serves as a plastic base when cutting the bullet shell into the rifling of the barrel) (figure 2.2.14 e).

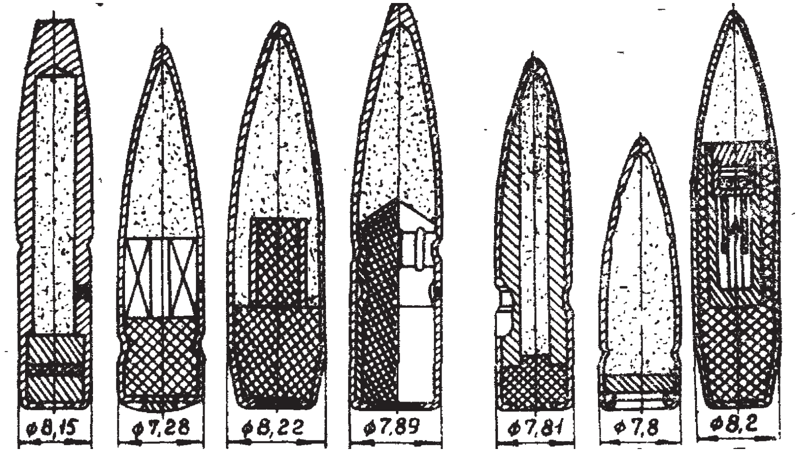
As a result of application of carbide cores of bullets of cartridges (9×18 Mak, 5,45×39) penetration of barriers and means of individual protection in comparison with bullets of usual cartridges (ammunition) improved.

Multi-element (special) bullets (tracer, incendiary, armor-piercing, incendiary, explosive, combined action) are used in combat (military) hand-held firearms (figures 2.2.20–2.2.24). The drawings depict bullets from the Second world war, but their elements are included in the design and modern bullets.



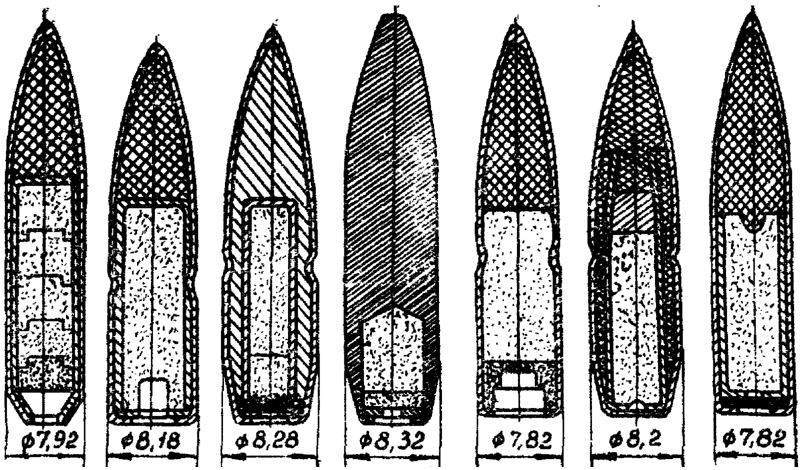
a b

Figure 2.2.19 — **System cartridge (ammunition):**
a — cartridge 7.65×17SR, equipped with a two-element shell bullet with a lead core; b — cartridge 9×18 Mak (57-N-181S), equipped with a shell three-element “surrogate” bullet with a steel core



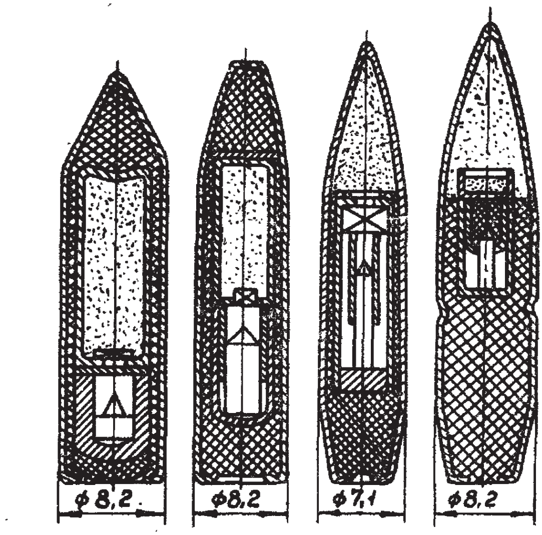
1 2 3 4 5 6 7

Figure 2.2.20 — **System tracer bullets:**
1 — T30 (USSR); 2 — England; 3 — Germany; 4 — France;
5 — USA; 6 — Czech; 7 — Finland



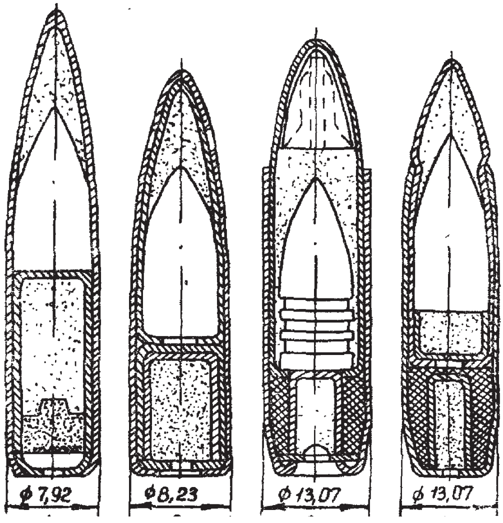
1 2 3 4 5 6 7

Figure 2.2.21 — **System incendiary bullets:**
1 — France; 2 — Spain; 3 — Poland; 4 — Japan; 5 — USA;
6 — France; 7 — Germany



1 2 3 4

Figure 2.2.22 — **System exploding bullets, slow-blow action:**
1 — Germany; 2 — Austria; 3 — Spain; 4 — Czech



1 2 3 4

Figure 2.2.23 — **System armor-piercing-incendiary-tracer bullet:**
1 — USSR; 2–4 — Italy

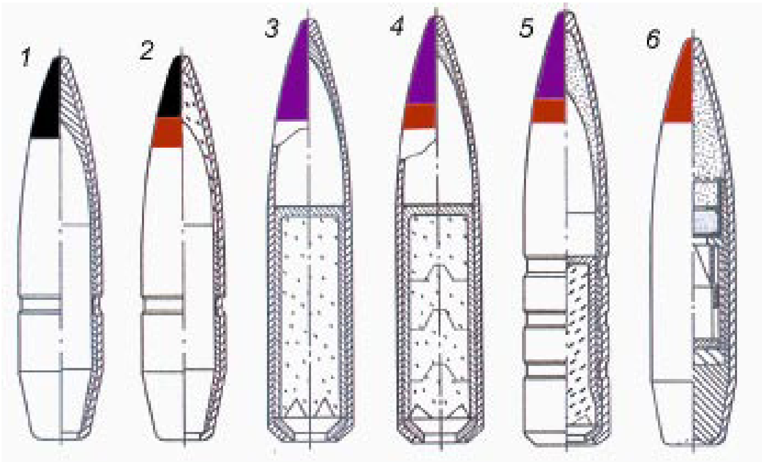


Figure 2.2.24 — **Special bullet cartridge 7,62×54R:**
1 — B-30 armor-piercing; 2 — armor-piercing incendiary (B-32);
3 — armor-piercing-tracer (BT); 4 — armor-piercing-incendiary-tracer (BZT);
5 — modernized (BZT; ZB-46); 6 — target-incendiary (ZP; PZ)

Development of cartridges (ammunition) with subsonic speed of the thrown element (“silent cartridges”) used in complexes of manual small arms with devices of silent and flameless firing (cartridges SP-5; SP-6; 12,7×55). Bullets data patrons (ammunition) provide sufficient zapregradnoe striking action on living goal on distances until 300 flushed (figures 2.2.25, 2.25.26).

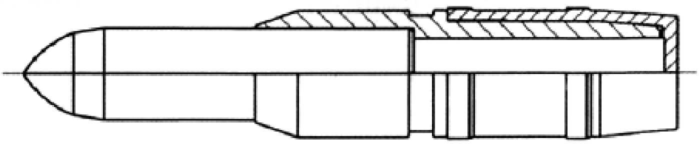


Figure 2.2.25 — **System multi-element bullets with tandem core cartridge (ammunition) 12.7×55 (SC-130 VPS)**

Bullet cartridge 12.7×55 (SC-130 VPS) has a tandem core. During a meeting with an obstacle, the armor-piercing core is embedded in it until it comes into contact with the shell, after which the shell stops. The cores come out of the shell, with the core located behind, transfers some of its kinetic energy to the armor-piercing, which breaks through the barrier.

Figure 2.2.26 — **Elements of a bullet with a tandem core of a cartridge (ammunition) 12,7×55 (SC-130 VPS) after defeat of the purpose**

Of particular interest is the projectile element of the cartridge (ammunition) used for firing from the automatic ADS (special two-medium machine). The design of the machine allows you to use it in two types of cartridges: cartridge 5.45×39 (7H6 and its modifications) and cartridge 5.45×39 PSP, corresponding to its dimensional characteristics (figure 2.2.27).

a b c

Figure 2.2.27 — **The bullet and the cartridge, the 5.45×39PSP:**
a — bullet cartridge 5,45×39PSP; b — cartridge 5.45=39PSP Assembly;
c — cartridge of 5.45×39 (7N6)

The use of the 5.45×39PSP cartridge of the new design of the throwing element provided the possibility of hitting targets not only in water but also in the air up to 400 m, which is practically comparable to the efficiency of the 5.45×39 cartridge (7H6) and distinguishes it from the previously used 5.66×39MPS cartridge with a needle-shaped throwing element, the effective range of hitting the target for which in the air was less than 50 m [198].

For shooting from modern sniper and rifled hunting firearms began to be widely used solid bullets made of copper alloys. It is noted in the literature that this improved the quality of their manufacture, minimized precessional and nutational oscillations of the bullet body on the trajectory and thereby significantly improved the accuracy of fire [44; 207, pp. 85–86].

As for cartridges (ammunition) for smoothbore firearms, the promising direction of improving the designs of the throwing element was the development of swept sub-caliber bullets with pallets of pulling, pushing and combined types made of polymeric materials [144].

Hunting bullet cartridges contain a cartridge case, a primer-igniter, a propellant charge and throwing equipment (a bullet or bullets). Depending on bullet design and method of manufacture the cartridges can contain a wad-seal the wad-seal with a damping element, the container, the container with a shock absorbing element, a composite container with two or more sectors and other auxiliary items.

A significant disadvantage of most hunting cartridges (ammunition), equipped with bullets of classical designs ("Sputnik", brennecke, Mayer, etc.), is the lack of reliable obturation, which reduces the effectiveness of smoothbore hunting weapons in its operation. The use of polymer materials in the design of bullet pallets for such weapons allowed to normalize intra-ballistic processes when fired, reduce the muzzle pressure of powder gases and thereby improve the accuracy of fire and increase the speed of the bullet. This became possible due to the fact that in the process of firing the pallet, expanding in radial directions, improves the obturation, performing "forcing" functions by increasing the coefficient of friction between the mating surfaces, as a result ensuring the effectiveness of the propellant charge and the projectile element of the cartridge (ammunition) [288, pp. 34–37]. Typical for these types of throwing elements are field bullets of all modifications, bullet Sauvestre and other types of sub-caliber bullets.

For shooting from smoothbore hunting firearms, expansive bullets with an increased damaging effect (for example, hexolit32 bullet) are also used, in the construction of which obturating rings made of polymeric materials are also used (figure 2.2.28).

a b c

Figure 2.2.28 — **The bullets of the cartridges (ammunition) for smooth-bore hunting weapons:**
a — swept sub-caliber bullet Polev-6U with a three-element pallet pulling and pushing type; b — Sauvestre swept sub-caliber bullet with two-element pallet of pulling-pushing type; c — expansive bullet of the increased striking ability Hexolit32 (at defeat of the purpose)

Most commercially produced shotgun cartridges (ammunition) are equipped with a polymer wad-container with a shock-absorbing link.

Wad-container provides protection of the primer-igniter and propellant charge from the influence of environmental factors, obturation of gunpowder gases when fired, pressure relief of gunpowder gases in the initial period of the shot and protection of the bore from the impact of shot. In accordance with GOST 28653-90 "Small Arms. Terms and Definitions" wad-container is a part of a sports (hunting) cartridge for small arms, designed to accommodate a shotgun shell and for obturation of powder gases (figure 2.2.29) [190].

Figure 2.2.29 — **Polymer wad container for shot**

The necessary elements of the wad container is circular bands in the zone of the obturator in the bottom of the container, and in some constructions and in front of the petals container. Ring belts facilitate the installation of wad container in the sleeve. In addition, in the annular belt located in the area of the obturator, there should be one or two slots for air outlet when installing the wad container in the sleeve. In the absence of slots, air compression occurs in the space between the bottom of the wad container and the powder, preventing the installation of the wad container in the sleeve until it stops in the propellant charge. Air outlet slots do not have a significant effect on the obturation of powder gases when fired.

Elastic thin-walled petals wad container should be connected to each other with a thin jumper or jumpers, providing a stable shape of the petals. The rupture of thin jumpers connecting the petals of the container occurs during the shot or after the departure of the wad container from the barrel. Under the influence of the incoming air flow, the elastic thin-walled petals are bent. As a result of the increase in resistance, there is a rapid braking of the wad-container, necessary for the smooth flight of the sheaf of shot.

Deformation of the wad-container damping link is a necessary condition for pressure relief of powder gases in the initial period of the shot. The shock-absorbing link can be additionally provided with lateral protrusions limiting deformation. With a significant transverse deformation of the shock-absorbing link that occurs when the shot is fired, the side protrusions rest against the walls of the sleeve, limit the deformation and serve as a load stabilizer.

The above-described operational advantages of using polymeric materials in the construction of welded elements of ammunition (ammo), despite their dignity, from the point of view of judicial-ballistic examination of these objects significantly complicate the task of identify a particular instance of small firearms, from which they were fired.

In addition to bullets, shot and buckshot (shot >5.0 mm in diameter) can be used in smoothbore hand-held firearms. Lead for shot can be mixed with tin, arsenic, antimony and other substances, depending on the content of which the shot is divided into hard (hot) and soft. Lead shot of industrial production is covered with a thin layer of graphite. In clad shot the lead ball is coated with a layer of Nickel or Nickel silver.

Depending on the diameter of the fraction is divided into: *small* (No. 10 – No. 6, with a diameter of 1.75 mm to 2.75 mm); *medium*

(No. 5 – No. 1, diameter from 3 to 4 mm); *large* (No. 0, 2/0, 3/0 and 4/0, with a diameter from 4.25 to 5.00 mm).

To determine the number of fractions with uniform mass and shape characteristics, it is necessary to lay 10 pellets along the ruler and measure the total length of the formed series of pellets (in mm). After that determine the average diameter of the pellets in D_{mean} by the formula:

$$D_{mean} = \frac{L}{10},$$

where D_{mean} — is the average diameter of one pellet (mm), L — row length of 10 pellets (mm).

The obtained value is compared with the reference literature and the fraction number is determined.

Table 2.2.5 — **Table of numbering and notation of fractions in different countries**

Pellets diameter, mm	Pellets number				
	Russia, Germany	USA, Canada	Sweden	England	Belgium
5.00	0000 (4/0)	T и O	11	AA	000
4.75	000 (3/0)	BBB	10	-	00
4.50	00 (2/0)	BB	9	BBBB	0
4.25	0	B	8	BBB	-
4.00	1	1	7	BB	1
3.75	2	2	6	B	2
3.65	-	-	-	1	3
3.50	3	3	5	2	-
3.25	4	4	4	3	4
3.00	5	5	3	4	5
2.85	-	-	-	$4^{1/2}$	6
2.80	-	6	-	5	-
2.75	6	-	2	$5^{1/2}$	-
2.50	7	7	1	$6^{1/2}$	7
2.40	-	$7^{1/2}$	-	7	-
2.25	8	8	0	8	-
2.00	9	9	00	9	8
1.75	10	10	-	10	9
1.70	-	-	-	11	10
1.50	11	11	-	12	11
1.25	12	12	-	dust	12
1.00	-	dust	-	-	-

The throwing element of hunting shotgun cartridges (ammunition) is an unordered collection of balls of lead pellets. For various types of hunting, cartridges equipped with lead pellets of different diameters can be used. Such cartridges (ammunition) contain a sleeve, a primer-igniter, a propellant charge, a throwing equipment (lead shot) and (or) a wad-container or a wad-obturator with a shock-absorbing link. The fraction withheld from precipitation in the cartridge rolling body shells, multi-beam star or strip by a circular rolling or pouring edge strip with a mixture of wax and paraffin in ratio of 1:1 (with makeshift equipment in a metal shell).

In the forensic study of hunting shotgun cartridges (ammunition) should take into account the high dynamic loads affecting the shot when fired. Axial loads on the fraction increase in the direction from the cut of the body to the bottom of the sleeve. Thus, the greatest load when pellets experiencing layers of shot adjacent to the bottom of the wad container or wad obturator. With excessive loads on the shot at the shot possible deformation of the pellets.

Load fraction and the likelihood of deformation of the fraction increases with increasing mass fraction, the increase of the length of the cartridge, reducing the height of the shock absorbing element of the wad container or wad of skirt, to increase the initial velocity of the fraction and pressure of the powder gases. Deformation of the pellets is typical for 12/76 caliber cartridges with an increased mass of the shot. For 12/89 caliber cartridges, the shot loads can reach such high values that the pellets are pressed into the bottom of the container and the pellets stick together in the layers experiencing the greatest loads.

Axial loads acting on the fraction when fired, also lead to the appearance of radial forces in the fraction. Radial forces pressing the outer layer of the pellets to the walls of the sleeve cause the braking of the pellets. Braking forces, in turn, depend on the number of pellets of pellets. For a small fraction with a large number of balls, the braking force is significantly higher than for a large fraction with a small number of pellets. Thus, the increase in diameter of the fraction, ceteris paribus leads to a reduction of inhibition of the fraction at a pellets, and this in turn — reduce pressure of the powder gases and increase the initial velocity of the fraction.

Cartridges (ammunition), equipped with steel shot, in the territory of the former USSR did not receive wide distribution. One of the drawbacks of cartridges (ammunition) of this type is the possibility of damaging the barrel of the gun as the result of exposure to steel pellets. The GOST R 50530 limits the diameter of the steel pellets, as well as the initial velocity and momentum when fired. In addition, in accordance with the requirements of the steel pellets must be completely in the container, protecting the bore from the impact of steel pellets. However, with homemade equipment, steel balls from rolling bearings can be used as pellets [200].

The main operational characteristics of hunting cartridges (ammunition), equipped with steel pellets, are its mass and initial speed.

The low density of steel compared to the density of lead causes a low mass of steel shot in the cartridge. Other things being equal, the weight of steel pellets is about 70 % of the weight of lead pellets. With the same diameter of steel and lead shot balls the ballistic characteristics of steel shot balls are significantly worse than the corresponding characteristics of lead shot balls and the speed of steel shot balls decreases faster on the trajectory. At the same time the low weight of the steel shot allows for a higher initial speed of the shot.

Hunting buckshot cartridges (ammunition) contain a sleeve, primer-igniter, propellant charge, propellant equipment (lead buckshot), powder gasket and gasket (cover) placed on top of the propellant. In addition, cartridges (ammunition) of industrial manufacture, equipped with buckshot, may contain a wad container or a wad obturator with a shock-absorbing link.

Unlike shot cartridges (ammunition) containing an unordered set of shot balls, buckshot cartridges (ammunition) under normal equipment contain an ordered set of buckshot balls. Buckshot balls should be placed in the cartridge in an orderly, parallel rows, containing from 2 to 5 balls. The diameter of the buckshot balls is selected taking into account the minimum gap between the balls in a row. Thus, there is a stable pattern between the inner diameter of the sleeve, the diameter of the buckshot balls and the number of buckshot balls in a row.

The arrangement of the rows of buckshot balls of the second and each subsequent row can be of two variants: above the corresponding balls of buckshot of the previous row; in the recesses between the balls of buckshot of the previous row.

In accordance with the current terminology buckshot is a large diameter shot. For equipment of hunting buckshot cartridges the buckshot KO (buckshot hunting) according to GOST 7837 is used.: 5.25; 5.60; 5.70; 5.80; 5.90; 6.20; 6.50; 6.80; 6.95; 7.15; 7.55; 7.70; 8.00; 8.50; 8.80; 9.65; 10.00 mm. For equipment of hunting buckshot cartridges, as a rule, auxiliary elements of the equipment intended for hunting shotgun cartridges are used (wads-containers of industrial production, self-made containers made of polymeric materials; matches, straws, wooden splinters placed vertically between the rows of buckshot; buckshot (shot) is poured with talc or potato starch to prevent crumpling when fired).

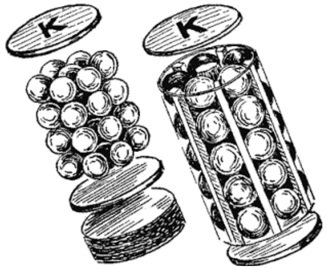


Figure 2.2.30 — **Placement of buckshot in the cartridge (ammunition) for smoothbore hunting hand-held firearms**

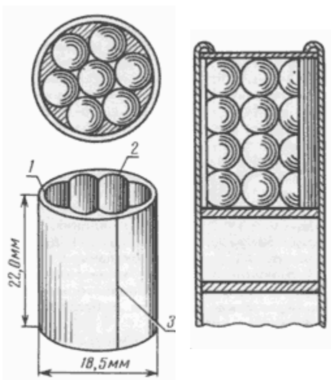


Figure 2.2.31 — **Polymer container for buckshot**

Axial loads acting on the buckshot when fired, lead to the emergence of radial forces in the buckshot. Radial forces press the buckshot balls against the walls of the sleeve and create braking forces. The number of buckshot balls is small, so the braking forces are negligible compared to shotgun cartridges (ammunition). Slight braking of buckshot leads to a significant decrease in the pressure of the powder gases and creates conditions for a significant increase in the initial velocity of the thrown element. When the weight of buckshot, slightly different from the mass of the shot, its initial velocity can be higher than the initial velocity of the shot at 30–50 m/s.

In forensic practice, there is a so-called associated buckshot, when buckshot in self-loaded cartridges (ammunition) are connected to each other by a metal wire or a strong thread "triangle" or "star" to improve the accuracy of fire.

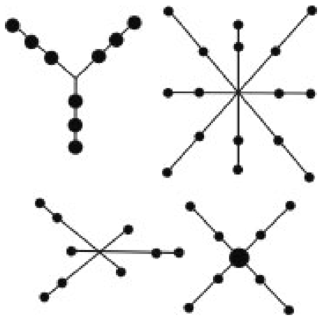


Figure 2.2.32 — **Methods of binding buckshot**

Proceeding from the stated, at production it is judicial-ballistic examinations of cartridges (ammunition) in research part of the conclusion the following characteristics of object of research shall be reflected:

for the cartridge as a whole:

– construction (state of visible structural elements);

– General weight and size characteristics (total length, weight);

for bullets:

– type (shell, semi-shell, non-shell), type (ordinary, special), as well as the shape of the head (pointed, oval, hemispherical, flat);

– dimensional characteristics (diameter of the leading part);

– sheath material;

– method of fastening in the sleeve (core, rolling, segment crimp, tight fit, etc.);

– color marking (if available);

– location relative to the cut of the sleeve body (protrudes, is below (above) the cut, recessed into the sleeve body — if necessary);

for shells:

– shape (cylindrical, bottle, conical);

– type (fully or partially protruding flange, flanged, with ledge);
– length;
– diameter at a cut (diameter of a muzzle in sleeves of the bottle form);
– diameter of bottom part (flange);
– the presence of a capsule (initiation device);
– type of capsule;
– the presence of traces of puncture of the capsule;
– the presence of flutes and other design features (if available);

for cartridges equipped with multiple throwing element (projectile) must be installed:
– a method of sealing (rolling) the shell casing and fixing the projectile (circular rolling, "multibeam star", gasket, etc.);
– markings (if any).

In addition, it is necessary to establish the individual characteristics of the object of study (the outer surface of the structural elements) in order to determine: the method of manufacture; defects; the presence of traces indicating a possible homemade equipment or re-ammunition factory production.

Thus, the following conclusions can be drawn from this section:

1. Improving the design of cartridges (ammunition) used for shooting small firearms, is through the development of new and modernization of existing elements of the design of cartridges (ammunition) with the aim of obtaining the necessary characteristics of action at a target in the shooting, raising vneshnepoliticheskikh characteristics, the possibility of breaking the existing and future personal body armor, due to the decision of specific tasks and manual small firearms (combat, service, civil), in which cartridges (ammunition) are used for firing.

2. The design of some cartridges (ammunition) does not contain a propellant charge (gunpowder) as an energy source, its functions are performed by an increased linkage of the pyrotechnic composition of the primer-igniter. At the same time, the energy characteristics of the striking ability of the thrown element (bullet) remain at a sufficient level to defeat the target. Consequently, the absence of a propellant charge in the design of such cartridges is not a basis for excluding them from the category of ammunition. The determining criterion for assigning such a cartridge to the category of ammunition should be sufficient to defeat the target value of the kinetic energy of the thrown element.

3. The widespread use of polymer materials in the design of the sleeve and the projectile element of cartridges (ammunition) significantly complicates their expert study in solving identification problems in the framework of forensic ballistic examination of these objects and the establishment of a specific instance of the weapon from which the bullet or sleeve was fired. One of the possible ways to solve this problem is the application of forensic marks on the parts of hand-held small arms, interacting with the elements of the cartridge design (ammunition) in the production of loading, firing, extraction and ejection, but this issue requires a separate scientific study.

4. Promising areas of improvement of the design (and its individual elements) of the cartridge (ammunition), the possibility of using some of their types for shooting in different environments (in air and liquid environments, mixed conditions), airspeed (subsonic and supersonic) are taken into account in the development of the author's classification, given in section 2.1 of Chapter 2 of the work.

Chapter 3
METHODICAL MAINTENANCE OF CRIMINALISTIC RESEARCH OF CARTRIDGES (AMMUNITION) TO MANUAL SMALL ARMS FIREARMS

3.1. Expert tasks solved during the examination of cartridges (ammunition)

Forensic ballistics, being a field of human activity aimed at the development and systematization of objective knowledge about specific objects of reality, combines special knowledge of a theoretical nature, as well as empirically accumulated data, which allowed it to become the basis of forensic ballistic examination as one of the traditional types of forensic examinations. Clarification of the content of forensic ballistic examination of cartridges (ammunition) and the possibility of using it in forensic and law enforcement activities necessitates the study of its essence, objectives, tasks to be solved within the framework of this examination.

Traditionally, in the legal literature, "special knowledge" is understood as a system of theoretical knowledge and practical skills in a particular science or technology, art or craft, acquired through special training or professional experience and necessary to address issues arising in the process of criminal or civil proceedings. Special knowledge usually does not include well-known and legal knowledge [221, p. 7]. Similar definitions of this term with some exceptions and additions are given in the works of other authors [203; 246]. In the dictionary and reference literature indicates that the word "knowledge" has two meanings: a result of knowledge, ie, a certain cognitive activity; a set of information in any area [183, p. 231].

In accordance with article 15 of the Code of Criminal Procedure of the Republic of Belarus (hereinafter — the CPC), an investigator or a person conducting an inquiry is obliged to take all measures provided for by law for a comprehensive, complete and objective investigation of the circumstances of the case [265]. To remove information from the material traces of a crime with the help of a person with special knowledge (expert), the legislation establishes the most rational way, which should correspond to the level of scientific and technological progress of society.

As noted in the literature, the worldview of the researcher shapes the focus of his thinking, the General and specific areas of scientific research, methods, principles and techniques, the means of knowledge; man as a subject of cognition in the process of existence expands your consciousness, i. e. conscious of the objective world through the study of the nature and phenomena of the objects; as a result, the conversion of the resulting research information is available for other people [289, p. 160].

This allows us to conclude that the expert study of cartridges (ammunition) as a cognitive activity, in turn, provides cognitive activity carried out by the criminal prosecution body. Being complex objects of the material world, characterized by different essence, properties and States, cartridges (ammunition) can be a source of information only after their proper research from the point of view of existing scientific concepts. The result of knowledge (actual data), obtained properly, is the ultimate goal of forensic ballistic research cartridges (ammunition) and intermediate-in relation to the objectives of the criminal process. In particular, R. S. Belkin and A. I. Vinberg note that "examination is always the establishment and explanation of the fact. Such facts can be the identity of the object, the presence of changes made in it, the suitability of the object for any action, etc." [13, p. 226]. The purpose of the application of special knowledge in the investigation of crimes is to detect, evaluate and study by a competent person with this knowledge, hidden forensic information that allows you to establish the facts that are essential to the case [302].

Being a complex phenomenon, the goal as an element of human activity consists of the following interrelated elements: subjective goal-an ideal image of the future phenomenon; material and spiritual means that are used to achieve the goal (legal, organizational, technical, etc.); object (thing, phenomenon or process), which is aimed at the subject-practical and cognitive activity; transforming activity of the subject [276, p. 534]. This fully applies both to the process of proof in General, and to the forensic examination of cartridges (ammunition).

The purpose of forensic ballistic examination of cartridges (ammunition) is based on the understanding of the purpose in a philosophical sense. In view of its dual nature, it can be considered both an objective and a subjective category, which manifest themselves depending on external conditions. The objective goal arises as a result of the influence of the facts of objective reality, reflects objective laws and is conditioned by them. The subjectivity of the goal stems from the fact that it is the result of conscious and organized activity of groups of people or an individual, existing in their consciousness, and is opposed to reality, because it expresses what is not yet [276, p. 534]. Thus the purpose defines features of activity of the person. V. N. Bibilo in relation to proving in criminal proceedings indicates that the expected result, which is the content of the goal, is not given by any, but by strictly defined actions performed in a strictly defined sequence, by strictly defined means [19]. A similar position is held by A. Yu. Vvedensky, who believes that the goal, acting as the end result of human activity (collective), predetermines the choice of appropriate means and a system of specific actions. It serves as a way of integrating various human actions into some sequence or system and acts as a direct motive, directs and reacts to various actions. It is the goal that is the main factor of the whole system for which it exists [33].

If from the philosophical point of view the goal is considered as "anticipation in consciousness of result on which achievement actions are directed" [276, p. 534], the when applied to forensic-ballistic expertise patrons (ammunition) under it should understand not removed any future, and only exclusively achieved through organized activities experts-faces, with appropriate ad hoc knowledge in science, technology, the arts, craft.

In relation to the type of forensic ballistic examinations studied in this work, the most justified is the consideration of the final and intermediate goals of forensic ballistic research of cartridges (ammunition).

In the philosophical sense, the ultimate goal is a stable, General, essential goal that expresses the main interests; it is the result, the completion of a series of successive actions associated with the implementation of intermediate (immediate and subsequent) goals. The need to separate the ultimate goal from other types (immediate, subsequent) is also due to the fact that the ways to achieve a common ultimate goal in specific conditions are specific [276, p. 534]. In relation to expert research, this division of goals has a conditional character, since as a result of cognitive activity and depending on the circumstances, the intermediate goal can become final and, conversely, the final goal-intermediate.

The foregoing allows to conclude that an expert study in forensic ballistic tests of cartridges (ammunition) is determined by the specific objectives, i.e. expected outcomes are ordered purposeful activities of a person with special knowledge used by law enforcement agencies in the implementation of production for materials testing and criminal matters. After determining the abstract model of the expected result, conducting appropriate research, the result of cognitive activity should acquire the necessary material-fixed form, reflected in the relevant conclusions contained in the expert's conclusion. In addition "since the criminal process has an informational nature, the special knowledge used in the field of criminal proceedings is used to explain the essence of the phenomenon under study (circumstances, material object) by means of directed assistance to the subjects of proof in the formation of evidence" [77].

The concept of the goal is closely interrelated with the concept of the task, which is understood as the formulation of specific issues to be addressed and consistently lead to the achievement of the desired result [183, p. 873]. Based on this, the tasks of forensic ballistic examination of cartridges (ammunition) can not be determined before the objectives and their priority are determined.

The task of forensic research as a logical-psychological category becomes such when it is presented to the expert for resolution. The expert understands it, defines it and looks for a way to resolve it. Thus, having understood the content of the task, having formulated it on the basis of the received task of a problematic nature, the expert performs a full cycle of productive thinking. Knowledge of the tasks solved in the course of a specific examination helps to understand what properties of the object are studied by this examination [29].

The doctrine of the types of expert tasks is currently one of the most developed in the theory of forensic examination. The subject of scientific discussions are the issues of building a system and classification of expert tasks. In relation to the forensic study of cartridges (ammunition) for hand-held small arms, expert tasks are based on the classification developed in the theory of forensic examination, according to which, according to the degree of generality of tasks, expert tasks are divided into *General*, *typical* and *specific*.

The General objectives of the examination determine its objectives in the most generalized form and outline the subject of examination of a certain kind (generic tasks of ballistic examination). Typical tasks of the type of examination, which are given in the reference literature, are formulated in relation to each object of this type and serve as guidelines for setting specific tasks (in this case — forensic ballistic examination of cartridges (ammunition)). Specific tasks are tasks assigned to an expert in the production of a specific examination of cartridges (ammunition)) [220, pp. 23–24; 221, p. 35; 222, p. 89]. From the above system of tasks in more detail consider the specific tasks of forensic ballistic examination of ammunition (ammunition).

Attempts of differentiation of expert tasks into separate groups by other criteria to have been in connection with the need of expert practices in resolving not only problems associated with identification (establishing the identity), but other tasks-finding properties as examined objects of judicial examination as a whole and their separate elements (properties and state of the research object) [95, p. 55]. Initially, these tasks were called non-identification [35] and were considered in the works of forensic scientists, including in the field of forensic ballistics [68; 180]. However, to agree with Yu. G. Koruhov, which indicates that forensic examination of a single-different categories of tasks that are permitted with this examination, therefore, speech should go not about the division of the forensics on the identification and opposite — deidentification, and the content of the task identification, diagnosis, classification, and possibly other, with a clear definition of their essence and specificity [107, p. 6].

On the basis of a number of theoretical works of forensic scientists, as well as analysis of the practice of various types of examinations, the opinion was formed that the content of forensic ballistic examination is wider than its narrow understanding from the point of view of the theory of identification, which was practically formed by the middle of the XX century. In the forensic literature it has been pointed out that identification is often the subject of forensic examination, but not the only one [255, p. 13].

Currently, most scientists (in particular, T. V. Averyanova, R. S. Belkin, A. I. Vinberg, Yu. G. Korukhov, N. T. Malakhovskaya) in their works distinguish four groups of expert problems: identification, diagnostic, classification and situational (situalogical) [38, pp. 159–160; 107, pp. 68; 110, pp. 432–433; 300, p. 129].

Forensic investigation of traces of hand-held small arms on elements of cartridges (ammunition) is carried out on the basis of the provisions of the theory of forensic identification. This theory is the doctrine of the General principles of identification (establishment) of various material objects on their displays for obtaining judicial evidence [15, p. 66].

The possibility of identification of rifled small arms firearms is based on the following theoretical provisions:

the doctrine of the individuality of trace trace-forming parts of small arms, interacting with the elements of the cartridge (ammunition);

the doctrine of the identification period and the relative stability of identification objects;

the doctrine of the mechanism of trace formation on the elements of the cartridge (ammunition);

the doctrine about dependence of display of signs of the microrelief forming traces of details of manual small arms firearms in traces depending on conditions of trace formation;

scientific provisions on the detection, fixation and removal of traces on the objects of forensic ballistic examinations;

provisions on assessment of properties and signs of the displayed traces of manual small arms at formulation of conclusions [95, p. 41].

Improvement of the theory of forensic identification and its conceptual foundations, developed by S. M. Potapov [213], supplemented by N. V. Terziev, G. M. Minkovsky and N. P. Yablokov, as well as other authors, the theory of "establishing group identity" [168; 255], allows us to define the theory of forensic identification in three aspects: as a private scientific forensic theory; as a research process; as a result of establishing identity, acting as evidence [230].

One of the main tasks of forensic ballistic examination is the task of establishing a sample of small arms firearms on its traces on bullets and casings. In the process investigations and disclosure crimes tools and means his committing are viewed, typically, in ties with establishing way committing crimes, personality criminal, however on some stage they can have independent significance, for example under search tools and the subsequent his identification for elucidation belonging suspect [71, p. 158]. The result of establishing group identity within the forensic and ballistic research in the initial phase of disclosure and investigation of crimes eliminated the inconsistency and uncertainty of the information received earlier, allowing the employee of body of inquiry (the investigator) to establish a causal relationship between specific facts, to check the validity of the previously submitted and to build a new version of the occurring event [72, pp. 5–8]. This circumstance is due to the forms of identification-the establishment of individual (group) identity and the establishment of the whole in parts.

A number of works by Soviet and Russian scientists are devoted to the theoretical substantiation of the establishment of group and individual identity, carried out in the framework of forensic ballistic examination [9; 60; 69; 79; 99; 100; 111; 112; 244; 248; 273; 274].

Currently, in forensic ballistics, it is customary to distinguish General and particular features peculiar to the individualized object of research, which is associated with a phased expert study of traces of hand-held small arms, displayed on the elements of the cartridge (ammunition) in the process of firing, which is characterized by a certain sequence [164; 165]. In addition, in the process of forensic ballistic examination, the object of study can be individualized only as a result of knowledge of the necessary set of its properties. From the above it follows that if the General characteristics of the object under study characterize all instances of manual small arms of the same model, the private — only its specific instance.

E. I. Stashenko proposed the division of signs of traces of the barrel of hand-held small arms into the following types: signs that display the features of the barrel of hand-held small arms; signs that characterize the qualitative state and degree of wear [244, p. 19]. It seems that this division is applicable to other parts that interact in the process of functioning of small arms not only with the bullet, but also with the cartridge case (ammunition), in particular the ejector, reflector, magazine, etc.

At identification of manual small arms firearms on traces on bullets and sleeves experts investigate, as a rule, the traces-displays characterizing individual features of a structure of trace-forming details of the mechanism of manual small arms firearms, abstracting from other traces which occurrence has no causal connection with the considered event.

With regard to the establishment of group (individual) belonging, the attribution of traces on bullets and cartridge cases (ammunition) to a group of models of hand-held small arms (a particular instance), as well as the division of signs into General and private facilitate the identification process, allow subsequently to exclude unreasonably advanced versions and facilitate the process of proof.

In this regard, the point of view expressed by B. N. Ermolenko B. M. Komarints is of interest, which is that the division into General and particular features is conditional, since a more detailed study of common features often leads to the fact that they pass into the category of private [70, p. 40; 101, p. 190].

In view of the above, the theory of "subclass signs" proposed by foreign scientists [306; 307] is quite justified. According to the proponents of this theory, these signs are traces of technological equipment of industrial equipment used in the manufacture of hand-held firearms, cartridges (ammunition) used for shooting from it. Such traces are formed as a result of the impact of the working parts of the tools during the production cycle and are displayed on the trace receiving surface in the form of static or dynamic traces.

In domestic of forensic science, such approach is widely used in technical examination of the products of mass production. Positive examples of the use of traces and production mechanisms on bullets in establishing a single source of origin, carried out in the framework of forensic ballistic examination, took place in the domestic expert practice [128].

Thus, the identification of hand-held small arms is impossible without interaction with the design elements of the cartridge (ammunition), which are the object-carrier of material traces formed as a result of their interaction with trace-forming parts in the process of preparatory, accompanying and final operations and firing processes.

V. A. Snetkov first introduced the term "diagnostic research" into forensic science [234]. This term (from the Greek. diagnosis-recognition, distinction, definition), borrowed from medical science, accurately indicates the essence and objectives of a significant amount of expert research, which is why finally established in the theory of forensic examination, including forensic ballistic [112, p. 106]. To approve I. V. Latysheva, based on scientific ideas forensic ballistic diagnostics as scientific knowledge of the expert diagnosis determines mainly the theory of criminalistic diagnostics and forensic ballistics, the totality of which creates the Foundation of scientific knowledge of diagnostic forensic ballistic expert studies [148].

A. R. Shlyakhov and V. F. Orlova in the work devoted to problems of classification of tasks of criminalistic examination as criterion of differentiation of tasks of judicial examinations allocated objectively existing divergences in their contents which are defined by the purpose and conditions of its achievement. According to these authors, the main elements of the expert task are the purpose and object. Thus it is noted that the purpose of diagnostic researches consists in establishment (reconstruction) of the occurred event in the past; establishment of the actions having character of private events makes the purpose of diagnostic researches and allows to allocate diagnostic tasks of examination [189].

T. V. Averyanova believes that the nature or state of a material object is the basis of diagnostic goals [3, p. 424]. A similar position is taken by S. V. Dubrovin, who defines forensic diagnostics as a forensic method of cognition, which is a system of cognitive techniques, the basis of which is the process of establishing the nature or state of the object having a certain relationship with the event of the crime under investigation [63, pp. 40–41]. According to A.V. Kokin, the subject of diagnosis is the essence of the object being diagnosed, which consists in the totality of its properties that are important for solving the problem, and it can be any information about the crime, contributing to the knowledge of this event [95, p. 59].

Thus, the generally accepted understanding of the essence of diagnostics and underlying laws does not yet exist and to date the content of its subject remains debatable. Nevertheless, on the basis of the above, it seems appropriate to support the point of view of I. V. According to which forensic-ballistic diagnostics — "the area of scientific knowledge of forensic ballistics, resolving mainly by means of forensic diagnostics and forensic ballistics questions of investigation of the nature, condition, properties and relations, event-related crime (offense), weapons, ammunition and traces of their actions, formulation on the basis of the data criminally significant value judgments about these objects, mechanism and other circumstances of the crime (offense)" [148].

When carrying out forensic ballistic examinations of cartridges (ammunition), not all properties of the object are investigated, but only those that characterize the object from the point of view of the question put to the examination resolution. Thus, the expert identifies the so-called informative features of the object under study, characterizing its properties. In relation to the forensic ballistic examination of cartridges (ammunition) for hand-held small arms, the diagnostic study establishes the suitability of the cartridge (ammunition) for firing, i.e., hitting the target as a result of a shot from the specified weapon, the compliance of the results with the established criteria [131].

At present, along with the diagnostic tasks solved in the production of examinations of cartridges (ammunition), the authors distinguish such a set of tasks as classification.

Proceeding from the generally accepted approach, classification studies include such studies in which the object is investigated and the task of the study is to determine to which class the object belongs [107, p. 68].

In General, the classification study can be considered as a clarification of the object belonging to a certain class. The class can be the only one, then the object belongs to itself. A class can represent a collection of homogeneous objects, and in this case, if the object belongs to a class, it must have at least one thing in common with this class [178]. V. F. Orlova and A. R. Shlyakhov defend the point of view, according to which "the classification problem is not an identification... the expert is not put before, and as a result of the study the goal of object identification is not achieved. It can not be considered diagnostic, because the object of study in the classification process is static, and the assignment of the object to the group is unequal to the establishment of an elementary particular event" [189, p. 8].

The specificity of this type of research is that a group (class), belonging to which should be established, is determined in advance. Such affiliation is established as a result of comparison of the parameters obtained in the course of expert research with a set of criteria defined for this class. A. A. Eisman characterizes this type of research as "determination of an object to a given characteristic" [295]. The same opinion, and N. V. Terziev, who believes that assigning an object to one or another group (class, subclass) is not enough to note the coincidence of certain signs, required a certain set; the content of the aggregate is determined by the classification of the corresponding objects defined by the criterion of practice [255, p. 27].

The decision of classification tasks of judicial-ballistic examination of cartridges (ammunition) on establishment of accessory of object to a certain class, in particular accessory of the cartridge to category "ammunition", involves application to the person storing it, norms of part 2 of article 295 "Illegal actions concerning firearms, ammunition and explosives" of the Criminal Code [266].

The founder of allocation of such type of examinations as situational (situalogical), is G. L. Granovsky who in 1977 as a result of generalization of expert practice formulated the basic theoretical provisions of criminalistic situational (situalogical) examination [50]. Subsequently, the position of the author was supported by other scientists, in particular A. I. Vinberg and N. T. Malakhovskaya, who identified in their work this type of expertise as an independent one [38, pp. 159–160]. It should be noted that the ideas of conducting such examinations were expressed by some scientists before. So, A. V. Dulov in 1957 pointed out: "In some cases, the examination should be appointed even when the situation of the scene is not violated… Thus, the investigator will provide the possibility of direct perception of the scene by the expert and will contribute to obtaining a more objective conclusion" [64, pp. 39–40].

The main objectives of situational (situalogical) examination are to establish the mechanism of the incident as a whole and its individual elements in the cause-and-effect relationship [62]; to determine the possibility or impossibility of the occurrence of facts in the specifically proposed circumstances.

In the course of situational (situalogical) examinations, spatial-temporal, substantive and causal relationships, material elements of the event are established [109]. In particular, in relation to the issue of expert research rounds (ammunition) solved the problem associated with the establishment of the possibility to use the murder weapon (gun) ammo (ammunition) specific type (cartridges replacement); the adequacy of the damaging properties of a welded element of the cartridge (ammunition) storage in specific conditions; the ability to display sledoobrazuyuschy parts manual small firearms on the construction elements of the cartridge (ammunition) specific of the manufacturer [1].

Thus, in the course of judicial-ballistic examination of the cartridges (ammunition) are solved by four main groups of tasks:

identification — identification (establishment) of various material objects on their displays;

diagnostic — understanding of the essence, identification of properties, determination of the state of the investigated cartridges used for shooting from small arms, elements of their design;

classification — differentiation of the studied objects and their assignment to a certain class (subclass) based on the established criteria;

situational (cytologically) — determination of the possibility (or impossibility) of the occurrence of the facts within the specified conditions.

It should be emphasized once again that the solution of certain tasks of the examination is due to the objectives of forensic research, which together with the object of the study determine the content of the methodology of expert research, as well as determine the sequence of application of appropriate methods and technical means, including forensic ballistic examination of cartridges (ammunition) as quite complex from the point of view of forensic examination of objects. Unambiguous understanding and clear differentiation of the purposes and tasks of forensic ballistic examination of cartridges (ammunition) is a significant condition for improving the quality of forensic activities and, as a consequence, the effectiveness of law enforcement practice.

I. V. Gorbachev proposed the following differentiation of tasks to be solved during the examination of cartridges used for shooting from small arms:

I. Problems about the type of model, caliber of cartridges and their elements. In this case, questions are raised about what kind of cartridge the cartridge belongs to; part of what cartridge is the bullet (sleeve, wad, etc.).

II. Problems about the type and model of hand-held firearms in which they are used for shooting. The following questions can be put to the permission of examination: for what manual small arms the given cartridge is intended; in what manual small arms the presented cartridge can be used for firing.

Based on the analysis of the content of these questions, it can be concluded that the semantic load and the volume of answers to the questions are unequal, since the second question is wider in content than the first. Which of the questions should be put to the permission of the examination, it is not possible to answer unambiguously and depends on the specific circumstances.

III. Tasks about establishment of a method of production of cartridges and their elements, a place and time of their release and the circumstances connected with production technology.

In respect of the present time on the territory of the Republic of Belarus there are cartridges (ammunition) of the World War II of Soviet and foreign production. Based on the results obtained during the expert study of these objects, the investigator (employee of the body of inquiry) can put forward a version of how they ended up with the suspect or in a certain place.

For cartridges (their elements) of self-made production it is expedient to pose the question, according to the type of industrial products they are made. To this group should also include the tasks associated with the technology of improvised (regear) rounds, with the production of the following issues: I whether filled cartridges with the use of devices; in this form were cast the study of the bullet is made whether the fraction using a single tool (fit).

The availability of on elements design patron (of ammunition) traces from use under their designing, equipment, peresnaryazhenii adaptations and equipment allows in some cases to decide question about unity source origin patrons, elements their design, materials, from which they are made.

IV. With regard to the individual elements of the cartridge, received for study in a disjointed form, the task can be set to establish whether they could previously constitute a single device [112, pp. 116–122]. Positive results of such studies have been obtained both in foreign and domestic expert practice in establishing the belonging of the bullet and the cartridge case to one cartridge [151; 215].

Nevertheless, in each specific case, the investigator (employee of the body of inquiry) is required to raise questions based on the specific circumstances and materials of the case, due to the subject of evidence.

Thus, on the basis of the above, the following generalized conclusions can be drawn:

1. The objective and subjective essence of the purpose of forensic ballistic examination of cartridges (ammunition) intended for shooting from small-arms firearms is determined by both the subject of proof and the existence of facts of objective reality, which ultimately determines the process of obtaining the necessary information about the object of research.

2. The solution of tasks within the framework of forensic examination of cartridges (ammunition) is determined by both final and intermediate goals (immediate and subsequent). The process of achieving them in each individual case is determined on the basis of a specific investigative situation. However the specified division is conditional, since the result of cognitive activity and depending on other circumstances, the ultimate goal could be an intermediate (further research will be conducted through a peer initiative) and Vice versa (in case of impossibility of solving the examination of the merits).

3. When carrying out forensic ballistic examination of cartridges (ammunition), not all properties of the object under study should be investigated, but only those that will allow to characterize it from the point of view of the question put to the examination resolution and are conditioned by the specifics of the relevant research. The list of such features should be fixed in the appropriate research methods of these objects, the implementation of which is aimed at improving the reliability and valid-

ity of the results. In particular, the determining criterion for assigning a cartridge to the category of ammunition is the possibility of hitting the target as a result of firing from the corresponding sample of hand-held small arms, i.e. ensuring the necessary ratio of mass, speed and size of the cross-sectional area of the thrown element.

3.2. Determination of the velocity of a single propellant element during ballistic examinations

Currently, the vast majority of forensic ballistic studies of hand-held small arms, ammunition is carried out in order to solve classification and diagnostic problems. Modern methods of expert research of hand-held small arms, cartridges (ammunition) used in it for firing should be based on knowledge of their internal and external ballistic characteristics, the processes occurring at a shot, use at carrying out expert researches of modern achievements of science.

The need for such an approach, due to the complexity of hand-held firearms, cartridges (ammunition), their versatility, the use of new materials and processing methods, technological processes in their manufacture, contributes to the development and improvement of means of obtaining quantitative measuring information about the properties of the object under study.

Providing the expert ballista with quantitative results of the velocity of the thrown element obtained as a result of experimental firing allows to establish functional connections between several physical quantities. In addition, obtaining reliable measurement information in the production of forensic ballistic examinations, in turn, ensures the reliability of the conclusions contained in the expert's opinion. This, in our opinion, cannot be explained in detail without taking into account the broad context, including the historical analysis of the development of ballistic measurements.

Experimental ballistics originated in ancient times, which was due to the need to obtain the maximum range of fire and action on the target of primitive artillery guns. However, providing artillery science with relatively accurate data on the ballistic capabilities of firearms became possible only by the middle of the XVIII century. During this period, as now, the measurement of the velocity of the projectile was made by indirect methods of measurement. For its determination, shooting from several guns installed with a single angle of elevation of the barrel was used, and if initially researchers were limited to the results of a single shot, by the end of the XVII century they began to use the arithmetic mean.

In view of the complexity of determining the speed of the projectile at different parts of its trajectory due to the force of air resistance, the researchers put forward the idea of measuring the speed in the immediate vicinity of the point of departure of the projectile — muzzle velocity. For the determination of this value by the French engineer and astronomer J. D. Cassini was designed ballistic pendulum — the first device designed to measure the speed of the projectile, the principle of which was to transfer the kinetic energy of the body of low mass to the body with a greater mass, resulting in its movement at a lower speed. Based on the descriptions contained in various literary sources, it was a wooden bar, moving on the surface as a result of being hit by a bullet. The main disadvantage of this method was that the coefficient of friction of the bar on the sliding surface was unstable.

In 1740, the British military engineer B. Robbins invented a swinging ballistic pendulum, which allowed more reliably determine the speed of the thrown element. On the basis of his experiments, Robins in 1742 published the book “New principles of artillery, containing certain forces of gunpowder and the study of the differences in the strength of air resistance for fast and slow movements”, in which he described his invention and the results of experimental shooting with its use. Structurally, this device of B. Robinson was a tripod tripod with a swinging iron pendulum suspended on a horizontal axis; a wooden bar 180–200 mm thick was attached to the body of the pendulum, designed to catch bullets [55, p. 139].

Subsequently, devices for measuring the speed of bullets began to be designed in France and Germany. Despite the fact that these devices did not play a significant role in the development of experimental ballistics, their individual components and elements were used later, in particular in electric spark chronographs.

Bothe in 1764 developed a device, the principle of which was to apply marks on a rotating drum. Based on the speed of rotation of the drum, the distance between the marks on it, the bullet speed between the muzzle and the target was calculated.

Italian Matei in 1773 developed a device for measuring the speed of a bullet, placing on a rotating axis of the drum with two cardboard discs, which were fired. The speed calculation was based on the rotation speed of the axis and the angle between the bullet holes in the discs. Later, the French Colonel J. Grober somewhat improved the design of this device, extending its axis and causing radius marks on the discs. The measurement error of this device was 1/20 of the true value of the speed. Despite further improvements in this method of measurement production, it has not received wide distribution [55, p. 145].

In 1831–1832 in France the device of measurement of speed of the thrown projectile based on the principle of use of the law of universal gravitation was tested. When fired, the bullet or projectile severed the cord passed through the system of blocks and holding the target. When the cord broke, the target fell, and the speed was calculated from the height difference from the suspension point to the hit point. The measurement error in this way was about 4 % [55, pp. 144–146].

The results of the combat use of artillery in the Patriotic war of 1812 and the Russo-Turkish war of 1828–1829 in the Russian Empire showed the need to improve existing and design new weapons, providing greater range and accuracy. Achieving this goal without the use of appropriate means of measurement, allowing to assess the parameters of the shot with the necessary accuracy. Robbins and Grober's methods were cumbersome and primitive, and did not allow to determine the speed of the projectile thrown at different parts of the trajectory.

An innovative approach to determining the value of the velocity of the projectile was proposed by Second Lieutenant, and later Lieutenant General of artillery K. I. Konstantinov (1818–1871), who owned the idea of using electrical phenomena (electromagnetism) in the design of devices for measuring the velocity of the projectile. Using the results of scientific works of famous Russian physicists of the time E. H. Lenz, P. L. Schilling and B. S. Jacobi, he proposed the use of electromagnets. As a result of the break of the power circuit of the electromagnets, the pointed rods ceased to hold, marking the drum rotating at a constant speed [104].

While abroad "for the collection of useful information related to artillery", K. I. Konstantinov made attempts to manufacture a device of his own design — an electroballistic chronograph. To do this, in 1840, he turned to the English physicist Charles Wheatstone, and later, convinced that the device assembled by the latter did not meet the requirements, to Louis Breguet, the owner of a firm for the manufacture of precision instruments in Paris. In 1844, the Konstantinov device was manufactured (figure 3.2.1) and demonstrated in action at the artillery range in St. Petersburg.

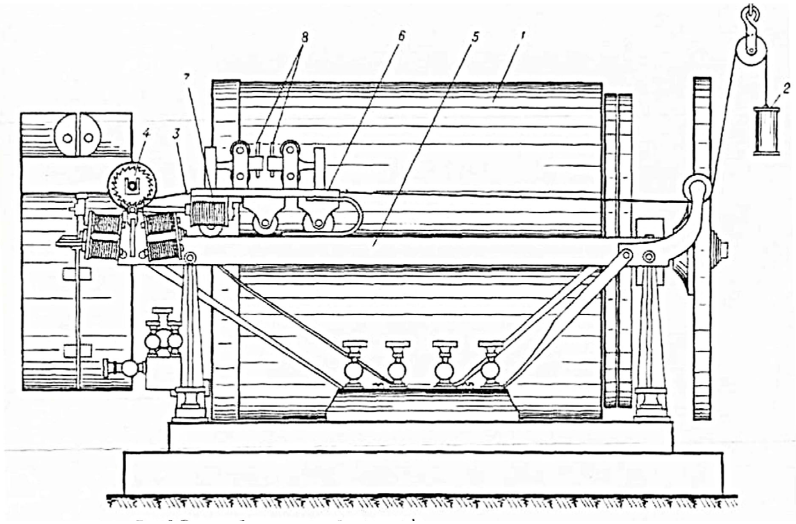


Figure 3.2.1 — **Electrophoretically chronograph by K. I. Konstantinov**:
1 — copper cylinder, 2 — cargo, 3 — cord, 4 — winch, 5 — rails,
6 — trolley, 7 — electromagnets, 8 — rods [104]

This device is several times superior to the accuracy of the ballistic pendulum, and also allows you to measure the speed on any part of the trajectory. Later C. Wheatstone and L. Breguet tried to challenge the superiority of K. I. Konstantinov in the use of electricity in ballistic measurements, but in 1847 fully recognized the authorship of the latter.

In connection with the use of rifling in the bore of weapons the number of inventions in the field of ballistic measurements of flight speed using electrical phenomena by the end of the XIX century has increased dramatically. The chronological series of these inventions can be presented in the following sequence: K. I. Konstantinov (1840, Russia), CH. Wheatstone (1842, England), L. Breguet (1843, France), J. G. Henry (1843, USA), Leonard (1846, Prussia), NAVET (1848–1849, Belgium), HIPP (1847, Grand Duchy of Baden), Vignotti (1854, France), Schultz (1857, France), M. de Brett (1858, France), Benton (1859, USA), Noble (1862–1863, England), P. le Boulanger (1863, Belgium), lers (1865, Belgium), F. Bashfort (1867, England) [104].

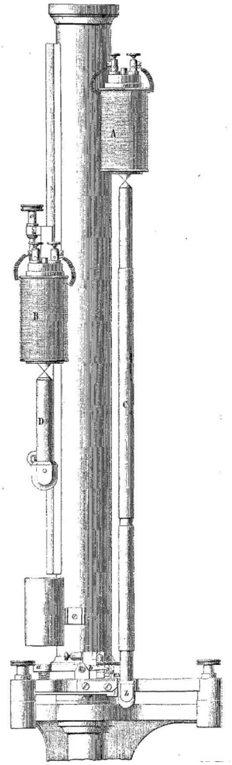


Figure 3.2.2 — **Chronograph by P. Le Boulanger** [179, p. 32]

To ballistic instruments measure speed by air, based on another principle, applies elektroballisticheskiy pendulum Nave, invented them in 1849 propulsion, time by air in which is determined by on street corner departures pendulum, beginning fall under rupture wire the first frame-targets. Devices with the same principle of action were subsequently designed by Vignotti (1855), Benton (1859), Lers (1865) and A. Shirsky (figure 3.2.3) [257, pp. 199–208].

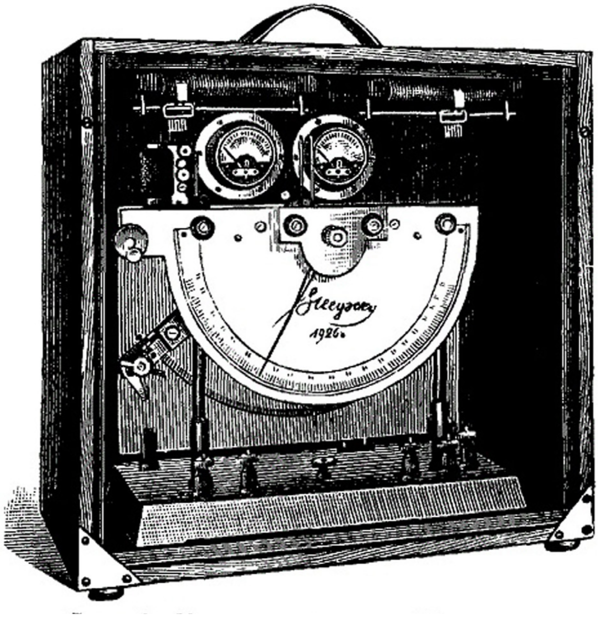


Figure 3.2.3 — **Millisekunder by A. Cherskogo** [given by: 257, p. 199]

Thus, by the beginning of the XX century, the main methods of measuring the velocity of projectiles were developed and tested, which were later borrowed from military science by forensic ballistics. It should be noted that the chronographs of P. Le Boulanger and A. Shirsky were used in the production of forensic ballistic examinations until the 1970s, until they were superseded by more advanced devices [257, pp. 83–84].

The methods used to determine the velocity of the thrown element can be divided into three main groups:

1) methods for determining the instantaneous velocity value at any point of the trajectory;

2) methods for determining the average speed on a certain section of the trajectory;

3) methods of continuous determination of the value of the velocity of the thrown element in different parts of the trajectory.

The first group of methods for measuring the velocity of the projectile element, namely methods for determining the instantaneous value of the velocity at an arbitrary point of the trajectory, include the ballistic pendulum method and the phenomenon of the formation of the head ballistic wave of a projectile flying at supersonic speed. By measuring the angle of the wave, it is possible to determine the velocity at a fixed point of the trajectory, which can be determined by a simplified formula:

$$v = \frac{a}{\sin\left(\frac{\alpha}{2}\right)},$$

where:

v — the speed of the throwing projectile;

a — the speed of sound in the air;

α — the angle of the shot ballistic waves [9, pp. 144–145].

The accuracy of the bullet velocity measurement with this method is about 5 %.

The second group of these methods, i. e., methods for determining the average speed on a certain trajectory based on determining the time of flight of the measuring projectile trajectory l. In this case, it is assumed that in the measured area the velocity of the projectile changes linearly, taking its average value for instantaneous. To reduce the errors introduced in the production of measurement, the length of the measuring section is selected as short as possible based on the allowable errors of the time interval registration [125].

The expert units use electronic chronographs, the principle of operation of which is based on the comparison of the measured time interval of the flight of the thrown element with the sum of the oscillation periods of the high-frequency quartz generator of electrical signals (KGVH) (figure 3.2.4).

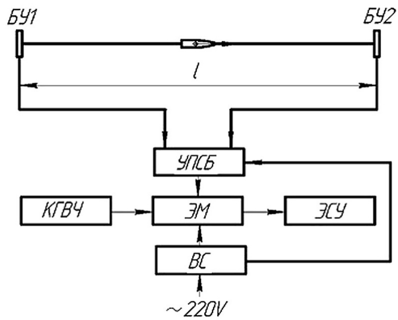


Figure 3.2.4 — **Block diagram of the chronograph device and operation:**
БУ1 и БУ2 — first and second blocking devices;
УПСБ — the device receiving signals of the locking device;
КГВЧ — high frequency crystal oscillator; ЭМ — electron multiplier;
ЭСУ — electronic reader; ВС — power supply [297, p. 105]

Currently, two types of sensors are used to block the beginning and end of the dimensional segment of the trajectory: contact and non-contact.

The simplest contact sensors are wire frames-targets with a wire spiral, as well as targets, the sensor of which is two sheets of metal foil, separated by a layer of dielectric material (paper). At the time of flight, the bullet opens (closes) the electrical circuit, starting or stopping the chronograph pulse counter. To ensure reliable rupture bullet of the winding wire to frame the target the distance between adjacent turns of 0,25 choose wire diameter. Winding at the same time is carried out with some tension to reduce the likelihood of pushing it to the sides and pulling.

Contact also include inertial sensors of the type that is installed as a secondary locking device. This sensor consists of a strong steel plate, which is suspended perpendicular to the plane of fire. The principle of operation of this type of lock is similar to the above. Chronometers with such blocking devices were widely used in expert institutions in 1960–1980. XX century (for example, the device LIS-2, made on the basis of decatron millisecond MS-1).

By non-contact methods of blocking include: acoustic, photoelectric and solenoid.

In the acoustic method, the blocking is carried out by two microphones that record the ballistic wave, which is formed during the flight of bullets flying at supersonic speed; at speeds below the speed of sound, this method is not suitable and practically does not change.

The photoelectric method of blocking is currently used in most of the devices for measuring the flight speed of the propellant element used by expert units (in particular, in the devices “Regula-6001”, RS-4M). When flying between a light source (led) and a photocell, the bullet crosses the light flux, causing an instantaneous change in illumination. The resulting electrical signal enters the electronic chronograph signal reception unit, controlling the pulse counter.

Solenoid interlock is based on the phenomenon of electromagnetic induction. The sensitive element of such blocking devices is the solenoid (inductor). This type of blocking is used in bullet velocity meters and IS-4 P, RUSH-MP, BIS-2. During the passage of the metal body changes the magnetic flux inside the solenoid and in the winding connected to the device receiving signals controlling the chronograph. A significant disadvantage of this type of blocking should be recognized as the inability to measure the speed of bullets made of polymeric materials.

Figure 3.2.5 — **The device of measurement of speed of flight of a bullet "Regula-6001"**

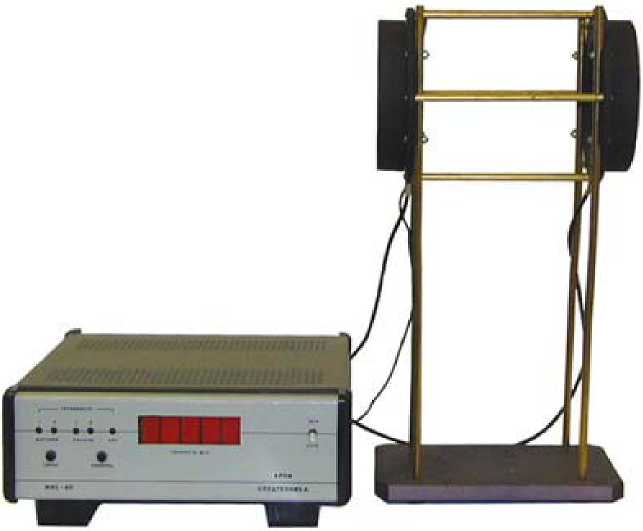


Figure 3.2.6 — **The unit of measurement of a bullet IIS-4P**

When measuring the velocity of the bullet, the blocking devices are placed on the trajectory so that the first blocking device is not affected by the powder gases formed during the shot (figure 3.2.7). Based on the analysis of established expert practice, the minimum distance from the muzzle of a hand-held small firearm to the first blocking device — $l_0 \geq 0{,}5$ m.

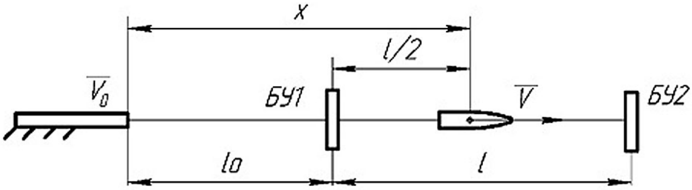


Figure 3.2.7 — **The layout is blocking the sensors on the trajectory** [297, p. 109]

The third group includes methods of continuous determination of the value of the velocity of the thrown element in different parts of the trajectory. Currently, measuring instruments are used in the design of which optical and radio principles of operation are used.

Optical measuring systems are goniometer devices designed for visual observation of a moving object. They are characterized by high accuracy and visibility of the obtained measurement results. For vneshnetorgovogo of determining the velocity of the methane element method is applied cinetheodolites. In this case, the direction-finding method of measurement is used, which consists in the fact that two or three kinoteodolitnyh posts simultaneously conducted photo-video of the movement of the thrown element in space.

Measuring equipment, the principle of operation of which is based on the radio principle of action (Doppler effect), has greater versatility and range. A moving projectile causes a change in the radio frequency signal directed at it. Based on the magnitude of the frequency change of the signal reflected from the object, its speed is determined.

As already noted, when solving diagnostic problems of forensic ballistic examination, means of measuring the speed of the thrown element are used. In accordance with the current regulatory legal acts, legal entities are obliged to ensure the unity of measurements in the production of products, performance of works, provision of services, reliability of the results of verification, calibration, metrological confirmation of the suitability of measurement techniques.

In this context, the approach of O. R. Matov and A.V. Stalmakhov is interesting, the essence of which is that since the method of determining the specific kinetic energy of the propellant element ($E_{spec.}$) in forensic ballistic examination is indirect, then the error of determining the $E_{spec.}$ should be calculated as an error of indirect measurement. The spread of speed values and the use of mathematical expectation (arithmetic mean) imply the presence of a random error, and hence the corresponding statistical processing of the measurement results. At value $E_{spec.1}$ = 0.555 J/mm^2, $E_{spec.2}$ = 0.66 J/mm^2, $E_{spec.3}$ = 0.775 J/mm^2, by calculating the standard deviation and error and estimating the confidence interval with a reliability of 0.95, the final value E_{spec} = (0.663 ±0,27) J/mm^2, in which part of the interval is less than the minimum value established in forensic ballistics E_{spec}≥0,5 J/mm^2 [159].

The authors propose two ways to solve the problem: to produce at least ten shots to reduce the confidence interval or, as required by the methods of research of objects of forensic ballistic examination, to produce three experimental shots. Thus it is necessary in each case to calculate the value of $E_{spec.}$ c taking into account the systematic error. Thus, if as a result of all three shots, sufficient values of the striking ability of the bullet are obtained, the second and third arrows will serve as confirmation that this measurement result is not "random".

The above allows us to make the following generalized conclusions:

1. One of the main tasks of the experiment carried out in the framework of forensic ballistic examination as the highest form of empirical methods of cognition of the properties and States of the objects of research is the organization of its production, including the selection of measuring instruments, metrological characteristics of which determine the reliability of the conclusions contained in the expert.

2. Requirements of metrological admissibility shall be fixed in provisions of techniques of the criminalistic research providing use of the empirical data received during experiment on the basis of which further calculations are carried out.

It seems that the accounting and the implementation of these insights would contribute to the compliance of measuring instruments, forensic laboratories and forensic investigation techniques to international standards, in particular the standard ISO/IEC 17025-2017 "General requirements for the competence of testing and calibration laboratories" and the development of a unified science-based requirements for forensic samples and techniques used in forensic ballistic examinations.

3.3. Diagnostics of the qualitative state of hand-held small arms used in the production of experimental shooting

A peculiar form of practice as a criterion of truth is experiment, which is a specific method of cognition of objective reality. By experiment, the investigated phenomenon can be isolated from the variety of other phenomena, facts and studied separately.

The method of the experiment is mandatory in determining the qualitative state of cartridges (ammunition) used for shooting from small arms firearms. In this case, the object of the experiment is the object itself (cartridge), while the indirect form of knowledge is excluded.

The analysis of law enforcement and expert practice confirms the need for mandatory experimental firing with measurement of energy characteristics of the thrown element of cartridges (ammunition) of homemade manufacture or re-loaded with the use of design elements of cartridges (ammunition) of factory manufacture.

In accordance with the provisions Of the methodology of forensic investigation of cartridges, the recommendations set out in the special literature on forensic ballistics, as a weapon used in the shooting of cartridges (ammunition) of factory manufacture, samples of factory-made hand-held small firearms with the appropriate parameters of the chamber and the barrel bore are used. This approach, due to the long-established expert practice of studying the properties of cartridges (ammunition), is described in detail in the works of famous scientists in the field of forensic ballistic examinations — V. S. Akhanov, V. A. Ruchkin, E. N. Tikhonov, A. I. Ustinov, etc.

Nevertheless, the issues of determining the qualitative state of hand-held firearms, available in full-scale collections of expert units and intended for the production of experimental shooting, have not yet been reflected in the forensic literature.

With respect to the subject it should be noted that in accordance with the established practice of small firearms in the Arsenal of organizations with a paramilitary structure, is subjected to categorization, i. e. the assessment of the degree of efficiency of a specific instance based on its quality status.

The classification of hand-held small-arms firearms into one or another category is not decisive in relation to hand-held small-arms firearms used in the production of forensic ballistic examinations. In this case, we should not talk about hand-held firearms, assigned to the employee and used in the exercise of his official activities, and experimental equipment designed to obtain criminally significant information about the object of research, in particular the speed of the projectile element of the cartridge (ammunition). Therefore, the requirements for such hand-held small arms should be different.

Hand-held small arms is a thermodynamic machine in which the released energy of chemical transformation is transformed into the thermal and kinetic energy of the movement of the system "throwing element-barrel". The phenomena occurring in the barrel channel of hand-held small arms when fired are associated with high pressures developed by gunpowder gases (1500–3000 at); high temperature of gunpowder gases (2.000–3.000 °C); short intervals of the phenomenon of the shot (0.01–0.001 s.).

Effects of physical and chemical factors that accompany the shot from a small firearm, interior dimensions, especially in the fields of the rifling, the initial section of the barrel (at the beginning of the rifling) and muzzle increase. Due to the wear of the bore, the ballistic characteristics of the shot change: the greatest pressure and muzzle velocity decrease, the technical dispersion of bullets increases.

The bullet cuts into the rifling occurs after it passes the worn section of the barrel channel (the bullet entrance) and by the beginning of the cutting will acquire some speed. Thus, depending on the degree of barrel wear, wear and tear of rifling, deterioration of the compression casing of the bullet its possible the "failure" of the rifling, a significant reduction in obturation, speed reduction and deterioration of accuracy of fire.

With a significant drop in speed (up to 10 %), an eight-fold increase in dispersion at the firing range or when cutting off the leading belts, the barrel of a hand-held small-arms firearm reaches the limit of ballistic survivability [46, pp. 57–58]. The influence of the degree of wear of the bore on the pressure in the discharge space and muzzle velocity is shown in the graphs (figure 3.3.1).

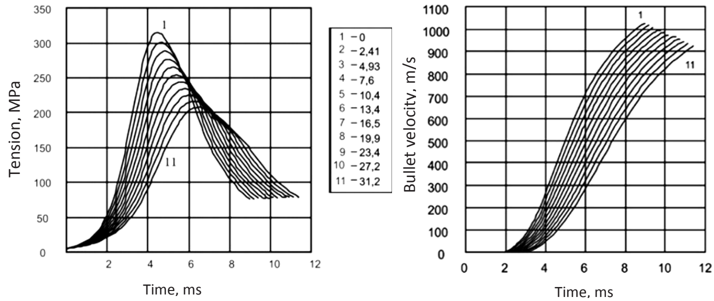


Figure 3.3.1 — **Change of average ballistic pressure and muzzle velocity depending on the degree of wear of the bore** [76, pp. 176–177]

In particular, for the majority of samples of manual small arms of the Soviet production check by the impassable caliber K-2 entered into a trunk from the muzzle section on a certain depth is applied. It is assumed that if the depth of the caliber entering the bore does not exceed the established values, the barrel has some (small) margin of survivability. Weapons with the same barrel wear is allowed for further use, provided that it satisfies the normal accuracy of the battle. Thus, in military and technical science, the main criteria for assessing the survivability of the barrel are:

1) drop initial speed of a bullet to a certain size;

2) increase of dispersion of bullets and emergence of failures of bullets from rifling [194, p. 114].

Table 3.3.1 provides data on the survivability of the bore of some samples of small arms of Soviet and foreign production [45, p. 138].

Table 3.3.1 — **The survivability of the bore of some samples of small arms firearms**

Type of hand-held small firearms	**Number of shots**
5.45-mm small-sized self-loading pistol (PSM)	3 000
5.45-mm Kalashnikov assault rifle (AK-74)	10 000
5.45-mm Kalashnikov light machine gun (RPK-74)	20 000
7.62-mm Shpagin submachine gun (PPSH-41)	20 000
7.62-mm submachine gun sudaev (PPP-43)	20 000
7.62-mm Dragunov sniper rifle (SVD)	6 000
7.62-mm Kalashnikov assault rifle upgraded (AKM)	10 000
9-mm Makarov pistol (Mak)	3 000
9-mm Stechkin automatic pistol (APS)	8 000
9-mm submachine gun MP-38 (MP-40)	20 000

In each case, the degree of wear of the barrel bore of small arms should be established individually using appropriate measuring equipment and by determining the consistency of ballistic characteristics based on the results of verification (certification) shooting. Only by meeting this requirements are to ensure objectivity and reliability in forensic ballistic examinations of the quantitative values of the speed of throwing item bullets (ammunition) [139].

Constancy of speed of the thrown element, proceeding from provisions of the theory of probability and mathematical statistics, it is necessary to make on ten test shots with measurement of speed of the thrown element. In this case, the average value of the speed deviation should not exceed ±20 m/s [297, pp. 113–115].

Before test from manual rifle firearms, enshrined in machine tool, produce one nezachetnyy shot for intermediate and rifle patrons and two shot being fired for pistol and revolver. Shooting should be made by cartridges (ammunition) of one party from one capping. In this case, the cartridges (ammunition) are kept at a temperature from 0 °C to 25 °C in a single layer in bulk for at least 1.5 hours — for pistol and revolver, 3 hours — for intermediate and rifle cartridges.

Velocity is determined as a result of shooting a group of ten shots, and then calculate:

the average speed — v_{mean}

$$v_{mean} = \sum_{i=1}^{10} v_i / 10.$$

For example, if the following results are obtained in the production of experimental shooting:

Table 3.3.2

Shot	1	2	3	4	5	6	7	8	9	10
Speed (m/s)	312	317	320	315	317	311	322	312	314	320

then:

$$v_{mean} = \frac{312+317+320+315+317+311+322+312+314+320}{10} = 316\ (m/s)$$

the highest value of the speed — v_{hv};
the lowest value of the speed — v_{lv};
the speed difference — v_{Δ}:

$$v_{\Delta} = v_{hv} - v_{lv} \quad .$$

The obtained value of ν_Δ is compared with reference data of ammo (ammunition) parameters used for test firing [297, pp. 113–115].

At the value $\nu_\Delta \pm 40$ m/s from the nominal values given in the technical documentation for the sample cartridge (ammunition), which was fired, the weapon must be recognized as unsuitable for use in the production of forensic ballistic examinations. The above values are used in assessing the quality of small arms in industrial enterprises and do not cause doubts.

Observing these recommendations, in our opinion, it is possible to objectively assess the qualitative state of the barrel of hand-held firearms used for the production of experimental shooting.

Important aspects of ensuring the constancy of the obtained high-speed characteristics of the projectile element of the cartridge (ammunition) include the purity of the bore of hand-held small arms and its length.

In this regard, of practical interest are the information given in the literature on the development of cartridges 7U1 (with subsonic bullet speed) to the Kalashnikov AK-74 (report of the Central Research Institute of Precision Engineering "TSNIITOCHMASH"). In the course production experimental called the shots from four new ballistic barrels and two barrels with large nastrelom were forthcoming the next data about speed bullets (table 3.3.3) [58, p. 172].

Table 3.3.3

Shooting practice	**New trunks**	**138 shots**	**370 shots**	**670 shots**	**1 250 shots**
Number of barrels	4	2	2	1	1
ν_{cp} (m/s)	240–279	271; 279	253; 254	254	284

One of the reasons for obtaining unstable values of v_{mean} when firing from different barrels is the braking of the bullet on the last section of the barrel, "when the pressure force of gases on the bottom of the bullet becomes commensurate with the forces of friction between the surfaces of the bullet and the bore. In this case, the state of the bore can have a greater impact on the velocity value, the lower the energy characteristic of the bullet. At the last 100 mm of the barrel ... at a certain state of the barrel bore, the bullet velocity can become decreasing" [58, p. 172].

This question is not new: "...it is noted that the velocity variation of subsonic bullets cartridges the greater the greater the length of the barrel of the sample weapon. Thus, when firing from a Degtyarev machine gun (RPD) with a barrel length of 62 caliber (club), the spread of bullet speeds was 47 m/s, Kalashnikov assault rifle (AKM) with a barrel length of 50 klb — 33 m/s. The spread of the values of VSR from the new Kalashnikov AKS-74U was 38 m/s (160 m/s from the AK-74) after firing 180 rounds of 36 m/s (from the AK-74 40–120 m/s)" [58, p. 179].

As a result of repeated experimental firing from ballistic barrels with a shorter barrel length, it was found that the spread between the barrels on the v_{mean} was 11 m/s instead of 44 m/s before the trunks were shortened. In addition, according to the report on obtaining stable results when working out a cartridge with a subsonic bullet velocity, the limits and stability v_{Δ} of the cartridges depend more on the copper plating of the bore, i.e. on the friction of the bullet, than on its parameters and purity of processing. After nastrela 180 shots cartridges 7N6, for cartridges 7U1 (with subsonic bullet speed) v_{mean} = 280–442 m/s, after cleaning v_{mean} reduced to 234–322 m/s.

Thus, the conducted studies have proved that pre-firing (180 shots) significantly improves the stability (reduces the spread of values) of the initial velocities of cartridges due to copper plating of the barrel and gunpowder deposits — smoothing of small defects of the chrome coating. In addition, there was a higher stability of the velocity of the projectile element of the cartridge (ammunition) when firing from hand-held small arms with a non-chrome barrel channel, due to the lack of "roundness" of the rifling after applying a layer of chromium.

As another determinant condition, it is indicated that intensive cleaning of the barrel of hand-held small arms with a barrel cleaning solution (RFS) for 2–3 days leads to the removal of copper plating and a decrease in the bullet velocity by 10–20 % [58, pp. 178–181].

Thus, to obtain stable characteristics of the experimental firing in relation to use of the respective samples of small firearms shall comply with the following conditions:

1) preliminary "run-in" of the bore of hand-held small firearms used in the production of forensic ballistic examinations, firing cartridges of one batch of at least 180 shots;

2) use to determine the suitability for firing cartridges (ammunition) of hand-held small-arms firearms with the minimum possible length of the barrel bore;

3) ban on the use of cleaning and lubrication of hand-held firearms used in the production of experimental shooting, active chemical com-

pounds with “Razmednitels” components of the artillery charge, designed to reduce the copper plating of the inner surface of the bore when firing shells with a copper lead belt;

4) check of ballistic characteristics of the specified weapon at least once a year with indication of its qualitative condition and quantity of the made shots.

It appears that based on the above conclusions and proposals would contribute to the improvement of forensic activities, having a positive effect on expert practice in determining the qualitative state of small firearms used in forensic ballistic tests of cartridges (ammunition), to determine their suitability for shooting, thereby ensuring the accuracy of the results of energy characteristics of the throwing element and the validity of the conclusions contained in the expert opinion.

3.4. Criteria for assessing the damaging ability of cartridges (ammunition) to hand-held small arms

Differentiation of objects of criminalistic research is one of the most important tasks solved in the framework of examination of cartridges (ammunition) used for shooting from small arms. In this case, of particular importance, taking into account the theoretical provisions and practical experience of expert units, is the definition of uniform criteria for assessing the damaging effect of the throwing element of such cartridges (ammunition).

For the correct understanding by the law enforcement officer of terms "weapon", "cartridge", "ammunition" at investigation of illegal actions diagnostic research of the specified objects used by suspects for the purpose of their relevance to the corresponding categories is carried out [269, p. 4].

A crime committed with the use of weapons is a system of actions United by a single intention and aimed at achieving a criminal goal. The functional purpose of small arms reflects the purpose of the criminal act [106, p. 23]. Such crimes are usually thought out and planned in advance, taking into account external conditions and factors. At the same time, the weapon used in their Commission is an integral determinant element of the system, since its technical and design parameters have a significant impact on this event.

The appearance of objects with new, previously unexplored or insufficiently studied properties entails the possibility of using them, including to achieve a criminal goal. In objects structurally similar to firearms, the same principle of projectile throwing is used, the striking ability of which is on the verge of the minimum level of striking ability established in criminology for small arms firearms, and this in turn allows the guilty person to store, transport such a device without fear of legal liability, which greatly facilitates the preparation and Commission of the crime.

Currently, in criminal law, there are three groups of objects whose striking properties are used in the Commission of crimes:

1) hand-held small arms, cartridges (ammunition) used for firing from it, gas weapons, explosive devices, etc.;

2) special means that have a direct impact on the human body for the purpose of temporary destabilization of its functions (including manual small arms of traumatic action);

3) objects used as weapons in the Commission of a criminal act [269, pp. 7–8].

In this paper, based on the purpose of the study, we consider only the striking properties of the projectile element of the cartridge (ammunition) used for shooting from hand-held firearms, as one of the main criteria for classifying cartridges as "ammunition" in its forensic meaning.

Diagnostically significant properties of cartridges (ammunition) as objects of expert research are their signs used in establishing the nature, properties and condition of these objects. Among the properties possessed by firearms, cartridges (ammunition) used in it for shooting, practical significance for diagnostic expert research are only some of them. In this case, the expert actually evaluates not the property, but its reflection outside (the reflection of the property is a sign) [106, p. 41; 149, p. 333].

The striking properties of the projectile element of cartridges (ammunition) used for shooting from hand-held small arms determine the actions of a person when committing a crime. Thus, when analyzing the localization of injuries caused as a result of the use of firearms of traumatic action, attention is drawn to the predominant defeat of the head and neck not only of the dead, but also of the wounded (table 3.4.1) [261].

Table 3.4.1 — **The distribution of injuries by localization**

Localization	The frequency of damage, %		The nature of injuries among the wounded, %	
	dead	injured	penetrating	non-penetrating
Head, neck	100	52,1	18	52
Chest	–	15,1	21	79
Belly, pelvis	–	9,9	16	84
Limbs	–	22.9	43	57

High frequency of penetrating wounds at shots in the head and a neck, and also extremities is explained by that in these areas shots are made most often from range of 1–2 m for the purpose of the guaranteed approach proceeding from characteristics of striking action of wounding shells of the applied weapon and vulnerability of their elements of clothes. In cases where it was possible to establish the distance of the shot, shots were fired from a distance of 1–2 m in 73 % of cases, from a distance of 2–3 m — in 7 % and from a range of more than 3 m — in 20 % of cases [261].

Thus, an integral characteristic of weapons in General and hand-held small arms is their effectiveness, reflecting the level of their functions. The impact of weapons on the target in ideal conditions, when it acts flawlessly, and the target struck by them does not have any resistance, is expressed in the maximum performance of the action on the target, which theoretically can provide a particular sample of such weapons. However, in practice, when used in each case, the weapon may (or will) at some point have indicators of action on the target below their maximum theoretical values. Since it is not possible to determine the maximum level of effectiveness of the action of the projectile element on the target, based on the above circumstances, then when committing crimes with the use of small arms, a reliable indicator of its effectiveness will be the minimum possible level of the striking ability of the projectile element of the cartridge (ammunition) [129].

To confirm this conclusion, it is advisable to comprehensively consider the system "munition — weapon — target". The deterministic conditions in relation to the question under consideration for this system will be the following:

1) the striking ability of the projectile element of the cartridge (ammunition) used for shooting;

2) susceptibility and vulnerability of the biological target to damaging factors;

3) type of hand-held small arms depending on the action of the loading mechanism and the number of charges — single-charge(multi-charge), automatic (non-automatic).

In the technical literature on the design of cartridges (ammunition) for hand-held small-arms firearms, the following types of striking action of a bullet on a target are distinguished: 1) lethal; 2) stopping; 3) penetrating; 4) armor-piercing [54, pp. 113–114]. It should be noted that for further study of the issue related to the definition of reliable forensic criteria for assessing the damaging effect of the projectile element of the cartridge (ammunition), theoretical and practical interest are mainly the first three of these types.

Studies in the field of wound ballistics and forensic medicine have shown that the impact of the thrown element on the target is determined by a set of interdependent types of such impact, the consideration of which is isolated from each other when deciding on the minimum striking ability is debatable. As M. B. Shvyrkov notes, the understanding of the features of gunshot wounds is possible only when taking into account the data of wound ballistics in conjunction with the anatomy and pathology of gunshot wounds [287, pp. 17–18].

At present, the lethal effect of bullets of cartridges (ammunition) to hand small arms is understood to be the action of a bullet that provides defeat of a living target due to violation of vital functions of the organism [54, pp. 113–114; 91, p. 7].

From the above definition, it follows that the lethal effect of the projectile element of the cartridge (ammunition) is to destabilize the functions and violation of the integrity of vital human organs. Violation of the anatomical integrity of the organ and / or its basic biological functions, as a rule, is irreversible and is caused by a complex set of pathological processes that develop as a result of the impact of the thrown element.

When considering such a damaging factor as the penetrating effect of bullets of cartridges (ammunition) used for shooting from small arms, it should be noted that in military science it is understood as the property of the bullet to penetrate through viscous barriers [54, p. 114]. In Forensic Science, the penetrating power of a bullet is usually understood as a damaging factor characterizing the hypothetical ability of a wounding projectile to cause damage to vital organs located in the abdominal cavity of the human body, which is expressed in a certain value of the specific kinetic energy of the thrown element [232].

An attempt to solve the problem of determining the minimum striking ability of wounding projectiles of small arms for solving the problems of its diagnostic study was undertaken by A. I. Ustinov. It consisted in the study of the damaging ability of pistol bullets cylindrical shape caliber 5.6 mm, 6.35 mm, 7.62 mm, 9.0 mm when shooting at the corpses of people from short-barreled rifled weapons. The impact of a bullet on the target was studied by these scientists from the point of view of the possibility of hitting the most vulnerable organs of the human body located in the abdominal cavity (liver, kidneys, intestines, spinal column, aorta) [267, pp. 16–17].

At the same time, the affected area was chosen by A. I. Ustinov on the basis of cases known in practice, when serious bodily injuries or fatal injury were caused by injuring projectiles having a lower flight speed (for example, when hitting the temporal bone or eyeball).

Thus, the German criminologist F. Hausstein described the case of a fatal wound of a woman who was at a distance of 60 m from a passing river vessel. When the bullet hit, the lens of the glasses and the eyeball were pierced, from which the 4.5 mm "Diabolo" bullet was extracted. One of the ship's crew testified that he fired an air rifle at seagulls sitting on the water. On the permission of examination the question is put: "whether energy of a bullet that after a ricochet from water it punched glass of points and eyes is Sufficient ?". In the course of the study, it was found that the glass of the glasses was destroyed at a speed not lower than 60 m/s and the bullet "Diabolo" had such a speed after the ricochet [308]. However, as noted in the literature, the area of both human eyeballs relative to the projection of the entire body area is about 1 percent, and therefore the probability of hitting it is relatively small [284, p. 79].

The essence of the experiment conducted by A. I. Ustinov was that since the shooting was carried out by bullets with the same shape of the head, the ability to inflict penetrating injuries depended mainly on their speed at the time of defeat. As a result, the scientists found that the minimum speed at which the possibility of causing damage by bullets of this form remains is 100 m/s (the results of the bullet velocity were rounded to the specified value) [267, pp. 16–17].

L. F. Savran, based on the data of the experiment conducted by A. I. Ustinov, for the first time introduced a new value into forensic ballistics — specific kinetic energy (the amount of kinetic energy per unit cross-sectional area of a bullet) [231].

$$E_{spec.} = \frac{E}{S},$$

where:

$E_{spec.}$ — specific kinetic energy of the thrown element (J/mm ^{2});

E — kinetic energy of the thrown element (J);

S — cross-sectional area of the throwing element (mm^2).

This value characterizes the energy load of the bullet per 1 mm^2 of its cross-sectional area, i. e. its penetrating effect [232].

In the work of L. F. Savran, data on the value of specific kinetic energy for bullets of different diameters (excluding the shape of the head part) are given (table 3.4.2) [232] taking into account the minimum limit of the defeatability, that is, the velocity of the wounding projectile (V_b) at the biological target should be $V_b \geq 100$ m/s [267, pp. 16–17].

Table 3.4.2 — **The value of the specific kinetic energy of bullets of different diameters**

The nominal caliber of the bullet, mm	Bullet weight, g	Bullet velocity at the lower limit of the damage, m/s	Kinetic energy of the bullet, J	Cross-sectional area, mm ^{2}	Specific kinetic energy of the bullet, J/mm^2
5.6	2,5	100	12.5	24.6	0.5
6.35	3,2	100	16	31.6	0.5
7.62	5,5	100	27.5	45.5	0.59
9	6,0	100	30	63.5	0.47

The results of the theoretical calculation of the specific kinetic energy for bullets of different diameters became the basis for the development of L. F. Savran "Methods for determining the minimum lethal force of standard and atypical firearms and ammunition" [232, pp. 17–20]. Currently, the value of the specific kinetic energy ($E_{spec.}$≥0,5 J/mm^2) is used in the methods of forensic investigation of cartridges, objects belonging to hand-held firearms, their serviceability and suitability for shooting [166] as a criterion for the minimum striking capacity of the wounding projectile (the projectile element thrown).

Opinion L. F. Savranya about how, that with criminalisticheskoy perspective specific kinetic energy ($E_{spec.}$) the most fully and accurately characterizes energy burden bullets on 1 mm^2 of its cross-sectional area and characterizes the penetrating power of bullets when hitting a biological target, has a reasonable character. However, for a full understanding of the essence of this phenomenon, it is necessary to additionally refer to the experiment conducted by A. I. Ustinov, who used rifled firearms of different calibers.

In spite of overall scientific significance of this experiment had some disadvantages:

first, as the main criterion, the possibility of destruction of certain (vital) organs located in the human abdominal cavity was chosen, i. e. only the penetrating ability of bullets was studied;

secondly, the movement of the wounding projectiles occurred at the lower limit of their stable gyroscopic stabilization in flight. At a speed of less than 100 m/s, the ricochet of bullets from the skin of biological material was observed;

thirdly, the penetrating power of bullets with a different (non-cylindrical — spherical) shape of the head part-oval and pointed-has not been studied.

In the framework of the issue under consideration, it is important to pay attention to the instructions of L. F. Savran that for bullets with a pointed and oval shape of the head part, this indicator may have a lower value [231; 232, p. 20].

In connection with the above, we note that to ensure a stable flight of bullets, two types of stabilization are mainly used:

the displacement of the center of resistance to bullets for the center of gravity by weighting the head part (characteristic arrow-shaped bullets);

giving the moving bullet a rotational motion around the longitudinal axis, as a result of which it acquires gyroscopic stability. The higher the rotation speed, the higher the stability on the flight path, respectively, when the rotation speed decreases below a certain limit, the stabilizing moment becomes overturning, and therefore the bullet sharply loses stability [90, p. 129].

The calculation of the angle of the rifling in the barrel of a small firearm is manufactured by industrial enterprises on the basis of certain parameters used for the shooting of it of the cartridge (ammunition): bullet shape, weight and dimension specifications, shell material, speed and others [54, p. 91].

Consider a specific example: determine the angular velocity of a caliber bullet d=5.6 mm at muzzle velocity V_1=280 m/s and V_2=100 m/s and the specified angle of rifling $\alpha=3^\circ$ (the angle of rifling in the corresponding samples of hand-held small arms for this caliber).

Solution: the angle of inclination of the rifling (α) corresponds to a certain length of the rifling stroke (η), at which the bullet makes one complete revolution around its axis, expressed in the number of calibers (clb). The value of the angle of inclination of the rifling (α) for each weapon model is obtained by calculation based on the steady flight of the bullet [90, p. 130, 133]:

$$\eta = \frac{\pi}{tg\alpha\,(3^o)} = \frac{3.14}{0.0524} \approx 60\,(clb)$$

Find the angular velocity of the bullet (ω_1) at muzzle velocity V_1=280 m/s and the angular velocity of the bullet (ω_2) at muzzle velocity V_2=100 m/s [90, p. 156]:

$$\omega_1 = \frac{V_{1\partial}}{\eta d} = \frac{280}{60 \times 5.6 \times 10^{-3}} \approx 833\,(rps);$$

$$\omega_2 = \frac{V_{2\partial}}{\eta d} = \frac{100}{60 \times 5.6 \times 10^{-3}} \approx 298\,(rps).$$

The analysis of the obtained results shows that when the muzzle velocity changes three times as much as the angular velocity of the bullet decreases, and this factor has a significant impact on its ballistic stability.

In addition, as noted by experts in the design of cartridges for hand-held small firearms, the flight of the bullet is influenced mainly by three groups of factors: 1) elastic vibrations (vibration) of the barrel at the time of the shot; 2) conditions of movement and deformation of the bullet in the barrel channel, depending on which (taking into account the eccentricity of the center of mass of the bullet and the deviation of its dynamic axis from the axis of symmetry) the initial conditions of firing are formed at the time of leaving the muzzle of the barrel by the bullet; 3) movement of a bullet on a trajectory [57, p. 125].

If we take into account that during the experiment A. I. Ustinov shooting was made from short-barreled hand-held small arms (pistols), as well as a small range of fire, the vibrations of the barrel as a determinant factor affecting the flight of the bullet, in this case can be neglected.

The second significant factor affecting the stability of the bullet movement are the processes occurring in the initial section of the trajectory. Theoretically the bullet at the time of departure gets straight, but because of raznoshennoy shell in bullets two- and three-element structures, misalignment of head and tail parts of the center of mass is always slightly offset relative to the axis of geometric symmetry. When the bullet cuts into the rifling of the bore and moves along the bore at the moment of leaving the muzzle the bullet acquires the initial angle of precession. The value of the specified angle is determined by the dynamic unbalance of the bullet formed during its manufacture, the asymmetry of centering when cutting into the rifling and movement in the barrel.

Leaving the barrel, the bullet changes its axis of rotation: instead of the axis of the bore on the trajectory of its rotation axis becomes a dynamic axis passing through the center of mass of the bullet. Therefore, the motion of a bullet in flight is the sum of two motions: precessional (rotation of the bullet around the dynamic axis) and nutational (aperiodic oscillatory motion). In combination with the withdrawal of the bullet in the direction of gyroscopic rotation, the movement of its center of mass occurs along a spiral curve that deviates from the direction of fire.

Precession movement occurs at a speed 20 times less than the angular velocity of the bullet, but with a large radius of rotation of the head [57, p. 126–127]. F. Mann gives information that the main influence on the flight of the bullet is influenced by the eccentricity of the center of mass (50 %) and precession-deformation oscillations of the bullet on the trajectory (30 %) [309].

Thus, at the time of departure, meeting air resistance, due to the separation of the center of gravity and the center of pressure of the bullet, its body makes forced precessional and nutational oscillations relative to the flight path and the longitudinal axis of the bullet, respectively (figures 3.4.1, 3.4.2).

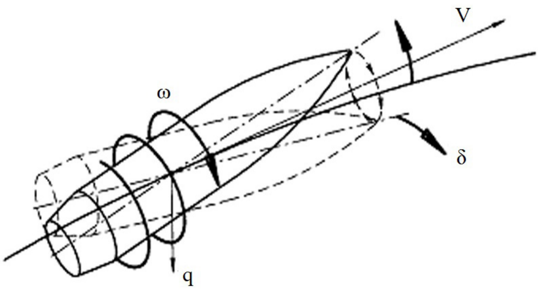


Figure 3.4.1 — **The nature of the rotating bullet movement:**
ω — angular velocity (rotational speed), V — the linear speed of movement,
δ — the angle of precession, q — acceleration of gravity [54, p. 91]

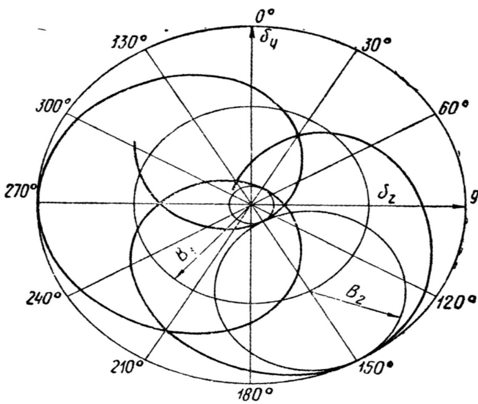


Figure 3.4.2 — **The nature of the motion of a rotating bullet near the center of mass**

The angle of these oscillations at the initial section of the trajectory of the bullet reaches 10°–15° and ends (the flight is stabilized) at a distance of about 5 m from the muzzle [184, p. 99], and therefore, the angle of its meeting with the obstacle at this distance is different from the normal.

So, for three-element bullet with a steel core regular cartridge 9×18Mak (51-H-181C) when shooting from pistol Mak on the phase of flight (2–23 m), the angle of precession is 37°–38°, due to the amount of rifling in the barrel, the magnitude of interference between the bullet and the barrel of his rifled pieces, the increased tendency of 9-millimeter bullets to the bias in pooling the entrance of the bore due to the length of the leading part of [57, p. 184]. It is these reasons that explain the ricochets of bullets at a target speed from 90 m/s to 115 m/s, recorded during the experiment by A. I. Ustinov [267, p. 14].

Thus, the conclusion of A. I. Ustinov that the lower limit of human lesions is due to the minimum velocity of the wounding projectile $V_{сн} \geq 100$ m/s, is hardly justified, since during the experiment, such factors as the shape of the head and the processes occurring in the initial section of the trajectory, on which the reliability of the results obtained depends, were not taken into account.

In 2003 A. G. Andreev made an attempt to repeat the experiment of A. I. Ustinov in the framework of the study related to the assessment of the damaging properties of homemade hand-held small firearms. Shooting was made by the reduced (reduced) charges according to the "top — down" scheme from a speed of 100 m/s and below from a hand-held small-arms firearm with a smooth barrel channel; biological tissues of an animal (pig) were used as a target [6].

During the pilot study established that the depth of penetration of the bullets with different shape of the warhead is sufficient to damage of vital organs of the human body, is achieved when the speed of the bullets ogive shape rounds of 5.45×39 is less than 60 m/s; bullets tsilindricheskoi form of cartridges 9×18Mak — more than 65 m/s; bullets tsilindricheskoi form of cartridges 5,6×10R — 110 m/s. Thus it became possible to define the minimum value of specific kinetic energy sufficient for defeat of vital organs of the person, at the various form of a head part of bullets of the following cartridges (ammunition): 5,45×39 — no more than 0,25 J/mm^2; 9×18Mak — 0,3 J/mm^2; 5,6×10R — 0,7 J/mm^2.

The results of the study allowed A. G. Andreev to conclude that the currently used value of the minimum specific kinetic energy, taken as 0.5 J/mm², is overstated — this value can be taken as 0.25 J mm², and that the difference in the shape of the head of the bullets (at equal speeds) affects the depth of their penetration into the barrier (biological target) [6, p. 107]. In addition, the author noted that bullets cartridge 5.45×39 at the given speeds were introduced into the biomaterial at an angle different from the normal, which is why the depth of their introduction in such cases was small [6, p. 105].

Similar results obtained under similar conditions (shooting the specified type of bullets with a reduced charge on the biomimitators — gelatin blocks), leads and V. N. Dvoryaninov, describing the tests of this type of bullets in the design of the cartridge 5.45×39: "when shooting on the reduced (reduced) charges, the nature of the movement of bullets in the control target is somewhat more unstable. The inlet openings are oval in shape, which indicates large angles of precession" [57; p. 485]. The above confirms the noted shortcomings concerning the conditions and results of experiments conducted by A. I. Ustinov and A. G. Andreev.

As mentioned above, the conditions of approach of the bullet to the target (before the immediate defeat) are determined not only by the speed of its translational motion, angular rotation, but also by the characteristics of precession-nutational oscillations, the values of which at the initial moment are random.

As an omission in the experiment conducted by A. G. Andreev, it should be noted that the 5.45×39 cartridge used by this researcher is intermediate and its bullet has other ballistic characteristics than bullets of pistol cartridges. To obtain more reliable results as a bullet with an oval shape of the head, in our opinion, it would be necessary to apply a bullet of a pistol cartridge 5.45×18 to a Pistol self-loading malogaba-ritnomu (PSM).

According to the technical task of the Ministry of internal Affairs of the USSR, one of the requirements in the design of this cartridge is minimal side effect of the bullets, in particular the scope of the temporary pulsating cavity formed by the bullet in said cartridge when conducting experimental firing at the design stage was 63 cm³ (bullet cartridge 9×18Mak (51-H-181C) — 130 cm³) [57, pp. 190–198], thereby minimizing the transfer of kinetic energy of the contacting tissues of the biomaterial in the moment of defeat and ensuring the maximum possible penetration depth in the target environment.

V. A. Fedorenko critically analyzed the results of the experiment conducted by A. I. Ustinov and the Method of determining the minimum lethal force of standard and atypical firearms and ammunition, developed by L. F. Savran, on the grounds that the lower limit of the biological target, characterized by a minimum value of the specific kinetic energy of the projectile 0.5 J/mm^2, is reliable only for wounding projectiles with a diameter of 5–9 mm and is characterized by a wedge-shaped action, indicating that the application of this criterion to the thrown elements of a different diameter (larger or smaller) is incorrect, since a change of the dominant striking factor is possible [269, p. 15].

The above allows us to conclude that the penetrating power of bullets largely depends on such a significant influence on the resistance to penetration into the target parameter as the shape of the head of the bullet.

As another parameter characterizing the damaging effect of bullets of cartridges (ammunition), it is necessary to consider the so-called side effect of the bullet in the defeat of biological tissues. It is known that a bullet fired from a hand-held small-arms firearm, when passing through soft tissues, forms a temporary pulsating cavity, exceeding the diameter of the bullet several times. For 5–10 microseconds, the cavity walls make forced damping pulsations and, colliding, destroy the integrity of adjacent tissue cells, damage capillaries and small vessels, cause molecular concussion and functional disorders; in addition, cells of tissues adjacent to the wound canal are damaged, causing a zone of secondary (sequential) necrosis [211, p. 26; 287, pp. 42–54].

Currently, the volume of the temporary pulsating cavity, according to experts in the field of wound ballistics, as an indicator of the characteristics of a gunshot injury is not yet scientifically substantiated, and therefore needs further, more in-depth study. There is no doubt only that the wounding projectile by virtue of its design features (shape, size, mass) and ballistic characteristics (speed, translational and rotational motion) in interaction with a certain organ forms a corresponding volume of a temporary pulsating cavity [80, p. 319]. As one of the criteria of the striking effect of bullets of cartridges (ammunition) used for firing from hand-held small arms, it is used by designers at the stage of their creation.

In particular, when shooting simulators for live tissues (blocks of 20 percent gelatin) assumes that pronounced damage of soft tissues with violation of the musculoskeletal function of the leg (severe limb injuries) occurs when the amount of the temporary pulsating cavity 350–600 sm^3, moderate damage with dysfunction of the limb segment (moderately wounded) — if the volume of 150–350 sm^3, slightly injured — in volume less than 150 sm^3 [57, p. 214].

In our opinion, the position of L. V. Belyaev, V. V. Kolkutin, I. Yu. Makarov and E. Kh. Mukhin on the study of the mechanism of formation of a temporary pulsating cavity by bullets of manual small firearms of oval shape at speeds below 340 m/s deserves attention. In particular, the named authors substantiates the mechanism of formation of the mentioned cavity in order that the dynamic impact of bullets and obstacles critical pressure deformation transmitted to the head part of the bullet (in the area of blunting the head portion) in the direction of its movement, resulting in the destruction of the damaged tissue (figure 3.4.3).

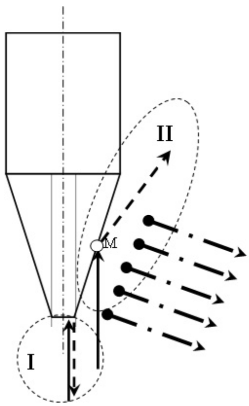


Figure 3.4.3 — **Scheme of interaction of the moving projectile with biological tissue at the normal position of the projectile** [176]

Biological tissues in contact with the head of the bullet at the place of its blunting (I) are reflected from the conical front part at an angle (II) in the "boundary" layer, i. e. directly at the point of contact (M), which is confirmed by the reverse emission of bone particles. Fabrics that are not directly in contact with the lateral surface are displaced perpendicular to the tangent of the lateral surface, i.e. forward and to the sides. This displacement of tissues, according to the researchers, is the "lateral" action of the wounding projectile, forming a temporary pulsating cavity [165].

This conclusion is confirmed by the indicator of the pressure distribution on the surfaces of the projectile at the time of flight on the trajectory, which is given in the literature on external ballistics (figure 3.4.4) [103, c. 24].

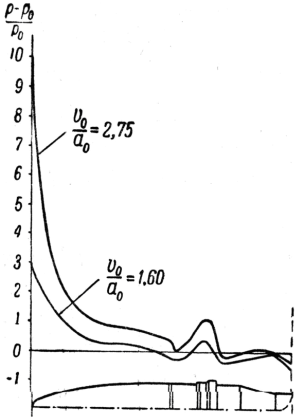


Figure 3.4.4 — **Pressure distribution on surfaces of the projectile** [176]

At bullet speeds in the range of 102–240 m/s the greatest pressure is exerted on its front surface (head part), at speeds in the range of 650–700 m/s — on its larger area. In this regard, the researchers justify the following conclusions: critical pressures are formed on the surface of the wounding projectile, reflect the tissues in the direction of its movement, thereby destroying them; a significant impact on the lateral action of the bullet at speeds below 340 m/s has a conical head of the bullet [176].

The analysis of the stated provisions concerning an assessment of various types of striking action of bullets, scientific substantiation of use of certain quantitative characteristics, other factors influencing morphology of a gunshot injury allows to draw a conclusion that the factors defining the mechanism of formation of a gunshot injury, are: 1) design characteristics of the wounding projectile (weight, shape, caliber, length); 2) features of bullet motion in the air (speed, precession-nutation oscillations, mass eccentricity); 3) anatomical and physiological properties of the affected part of the human body.

The ability of a bullet cartridge (ammunition) to hit a biological target depends on its design features and ballistic properties. Practice use of manual rifle firearms has shown, that action wounding projectiles on goal in moment destruction expands under other equal conditions with increase in diameter bullets, speed under meeting with goal, reducing length (blunting parent parts of), with violation of forms (deformation) under strike, sustainability its movement in body [89, p. 8].

The position of V. A. Fedorenko seems to be correct, who notes that the properties of a wounding projectile can be characterized by several types of damaging action at the same time, but at present no forensic methodology has been developed to assess the possibility of damage as a result of the simultaneous action of several damaging factors [269, pp. 9–11]. As a solution to this problem, the author suggests using the following: with the simultaneous action of N independent damaging factors, the total probability of defeat G is determined by the formula:

$$G = 1 - \prod_{i=1}^{N} (1 - G_i),$$

where G is the total probability of defeat, N is the number of considered damaging factors, Gi is the relative probability of defeat due to the action of the i^{-th} damaging factor, N is the sign of the product [269, p. 11].

Example: the calculation showed that the relative probability of damage to G1 due to the formation of a temporary pulsating cavity is 0,4 (40 %), and the relative probability of penetrating action G_2=0,6 (60 %).

Solution: the relative probability of hitting the target as a result of the combined impact of these damaging factors is equal to:

$G = 1 – (1 – G_1)×(1 – G_2) = 1 – (1 – 0.4)×(1 – 0.6) = 0.76$ (76 %).

The given approach has reasonable character from the point of view of the probability theory, but as separate types of striking action of bullets on a biological organism are not sufficiently studied and their minimum threshold values are not defined, now the specified technique of determination of set of striking factors cannot be applied in judicial ballistics. And these shortcomings are pointed out by the author himself [269, pp. 13–14].

If the criterion of the minimum striking ability was originally developed for expert research of single-shot manual small arms of primitive design, now for an assessment of striking ability of this or that type of the cartridges (ammunition) used for firing from manual small arms, it is necessary to consider also characteristics of vulnerability of the purpose in relation to injuring shells of multi-shot manual small arms or products structurally similar to it (automatic pistols or revolvers), allowing to make a series of shots in a relatively short time interval (1–2 sec.), the number of which depends on the capacity of the magazine or drum.

Thus, for research in expert institutions of the Republic of Belarus, the Russian Federation and Ukraine receive new samples of devices structurally similar to hand-held small arms, for shooting from which the Flaubert cartridge is used. The specific kinetic energy of the propellant when fired from such devices is below the generally accepted level in forensic ballistic examination of the minimum specific kinetic energy ($E_{spec.}$≥0,5 J/mm^2) and is within 0,34–0,47 J/mm^2.

In particular, the experimental shooting of these devices was carried out in the State scientific research forensic center of the Ministry of Internal Affairs of Ukraine. The shooting was carried out on the corpses of people (in the projection of the torso) on the basis of the Kiev Bureau of forensic medical examination from revolvers "ME-38 Magnum-4R" и "ALFA mod.461" cartridges produced by Dynamit Nobel (Germany) and Sellier&Bellot (Czech Republic) from a distance of 3–5 m. According to the results of medical and biological research, the corpses were damaged, with signs of moderate and mild severity [305]. However, there is evidence that these devices, which do not meet the forensic criteria for classifying them as hand-held firearms, are at the same time capable of causing fatal injuries when a bullet hits the victim's head [304].

As one of the ways to solve the problem of determining an objective criterion lethality should consider such characteristics as the conditional law of destruction G(m) that determines their effect on the single target, which implies a probability of damage when it hit m shells. The characteristic of the conditional law of defeat is the average required number of hits— ω, hich is the mathematical expectation of the number of hits at which the target is considered to be hit [10, p. 13]:

$$\omega = \sum_{m=0}^{\infty} \left[1 - G(m)\right].$$

The meaning of this law can be expressed by the following properties:

1) $G(m) = 0$ — in the absence of hits the target will not be hit;

2) $G(\infty) = 0$ — with an unlimited increase in the number of hits the defeat of the target becomes reliable;

3) $G(m)$ — non-decreasing function m (with an increase in the number of hits, the probability of hitting the target can not become less).

Example: the target you want to hit consists of three zones (conditional division): zone A, zone B and zone C (figure 3.4.5).

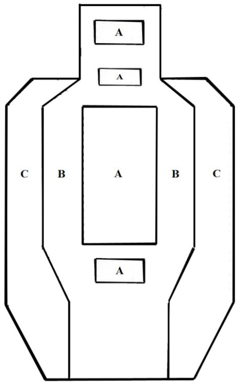


Figure 3.4.5 — **The affected area of the biological target (division conditional)**

When hit by a bullet in the area A the goal is considered to be affected; getting into the zone B cause damage, insufficient to defeat a target, and the second hit in this area entails a loss of purpose; the area C the least vulnerable, to defeat a target you must hit it at least three painful rounds.

Since man is a biological organism, he has the "property of accumulation of damage" [10, p. 13], which consists in the fact that the target can be hit by the combined damaging effect of two or more shells, none of which is individually able to hit the target. The target can be hit by one hit in zone A, one hit in zone B, a second hit in zone C, etc. Thus, the average number of hits required is equal to the sum of all additions up to one of the defeat law G(m).

To assess such an impact on the target V. A. Fedorenko proposes to use the method of calculating the total volume of damage caused by injuring projectiles, used in the forensic evaluation of the fragmentation effect of a hand-held offensive grenade [218, pp. 36–40; 269, p. 14]. If each individual wound projectile did not have enough energy to hit the target, it is necessary to calculate the total volume of wound channels ($V_{w.c.(joint)}$); at value $V_{w.c.(joint)}$>6 sm^3 it should be considered that the lower limit of the defeat of the target has been reached. The volume of the wound canal ($V_{w.c.}$), ormed by one striking element, is determined by the value of the specific kinetic energy ($E_{spec.}$) [232; 267]:

$$V_{w.c.} = 6{,}7 \times E_{spec.} + 1{,}17 \text{ (sm}^3\text{)},$$

where E_y — is the specific kinetic energy of the thrown element (J/mm^2).

The sum of volumes of several wound channels will make the total volume of defeat of the biological purpose at action of n — wounding shells:

$$V_{w.c.(joint)} = V_{w.c.1} + V_{w.c.2} + ... + V_{w.c.n} \text{ (sm}^3\text{)},$$

where n — the number of wounding projectiles.

Taking into account the considered properties of system elements "ordnance — weapons — aim" with regard to the defeat of the biological targets of many wounding rounds with the level of specific kinetic energy below the set limit, but close to it, from repeating devices in a short time period (several seconds) to produce a series of shots at a single target (revolver, automatic pistol, etc.), such items would be appropriate for the firearms based on the amount of their total effect on a biological target that has a property of accumulation of damage [129].

Based on the above, it can be concluded that since it is possible to cause serious bodily injury or death from devices designed for firing Flaubert cartridges, then taking into account the injuries caused in the framework of a comprehensive forensic and ballistic study, such devices should be attributed to firearms.

Questions of interaction with biological tissues of the person of the thrown element of the cartridge (ammunition) till now in judicial ballistic examination remain not studied that is caused by a number of factors. To clarify the minimum quantitative value of the specific kinetic energy of the propellant element used in forensic ballistic examination when firing from small arms, we carried out experimental firing on biological material.

As previously stated, the characteristics of the affected area of the biological object in each case is random, but the result of the interaction of system elements "throwing item — target" is probabilistic, while the level of resistance of the tissues of the biological object is characterized by the probability distribution of penetration or no penetration depending on the properties of the wounding projectile (shape, speed), density, and structure of the targeted biological tissues, etc. There is no doubt that the resistance of biological tissues to the effects of single low-speed (<340 m/s) throwing elements can be determined in the course of experimental shooting under controlled conditions. As an imitator of human tissues, as a rule, the tissues of the pig breed “large white” weighing 50–60 kg are used [184, p. 259].

Because the properties of the tissues for each species individually, we in the production of the experimental firing was chosen as a criterion, reflecting the interaction of system elements “throwing item — target”, as the limit of penetration, characterized by the value of speed of throwing item where the probability of a through-penetration or no penetration of the tissues of the biological object is 50 % (v_{50}).

The above parameters for assessing the susceptibility of tissues of a biological object to the action of a wounding projectile are due to the assumption that the higher the velocity of the thrown element, the higher the probability of penetration of the biological object, other things being equal.

Considering the resistance of tissues of a biological object to damaging factors from the point of view of probability theory and mathematical statistics, based on the level of confidence probability and depending on the number of experiments and the number of penetrations, it is possible to determine the lower limit of the probability of penetration.

The characteristic of resistance of tissues of a biological object to penetrating action of a wounding projectile is a statistical value. In experimental determination of the parameter v_{50} we carried out experimental shooting given the charges, during which they established a minimum rate of methane item (bullet cartridge 5.45×18) under the scheme “up — down”, i. e. reducing its speed in the next experience after getting penetrated tissue (destruction of the biological object) or an increase in the result no penetration.

At the same time, the following were experimentally determined:

$v_{\text{max notpenetration}}$ — the maximum value of the velocity of the thrown element, at which the penetration of tissues of the biological object was not achieved, and above which only cases of penetration were observed;

$v_{\text{min penetration}}$ — the minimum rate of penetration of tissues of the biological object, i. e. the rate below which penetration during the experimental shooting was not observed.

As a result of the experimental study, it was assumed to obtain a zone of mixed results (in which both penetration and non-penetration of the biomaterial is observed).

In relation to the above conditions of production of experimental shooting, the conclusion about the non-penetration of the tissues of the biological object at a very low speed of the thrown element, as well as a reliable penetration at a significant speed, seems reasonable.

During the experiment, we used a biological sample of tissues of the anterior abdominal wall of a pig of the breed "great white" with dimensions of 400×200 mm, thickness of 3–5 cm, most fully meeting the requirements in terms of reliability of the results obtained and corresponding to the structure of human tissues.

The zone of mixed results (penetration and non-penetration) in this case fully corresponds to the theory of probability and mathematical statistics used in the processing of experimental knowledge. In the specified range it was necessary to receive not less than 5 nonbreaks at speeds less than $v_{\text{min penetration}}$ of samples and accordingly not less than 5 breaks at speeds more $v_{\text{max notpenetration}}$.

It was assumed that in this case, the values of breaks and non-breaks will be in some range of speed values, provided that they do not go beyond the range ±10 м/с. In addition, when conducting experimental shooting, the ratio of the results of experimental shooting, in which there is a through penetration of the tissues of the biological object, and experiments in which it was not in the scoring range of speeds, approached 50:50.

The distribution of the non-breaking frequency depending on the velocity of the thrown element was determined by calculation using the following assumptions:

all tests are independent;

the result of each test is alternative: penetration or non-penetration;

the nature of the change of probability of no penetration of the sample by changing the values of the rate — monotonic (increasing speed is time-housego item, the probability of no penetration decreases).

Shooting was carried out at a distance of 5 m from the biological object, with the measurement of the velocity of the projectile element of the weapon with a smooth bore length of 12 calibers to exclude the influence of precession-nutational oscillations on the introduction of the bullet into the barrier. Scoring were hits in which the bullet was embedded in the tissue of the biological object at an angle 90°.

In the range of the velocity of the throwing element during the experimental shooting from 58 m/s to 73 m/s, a zone of mixed results was observed, the ratio of breaks and non-breaks in which is 50:50. In the specified interval produced 25 scoring shots. Below the speed of 58 m/s there was a 100 percent non-penetration of the biological object, and at speeds above 75 m/s — its 100 percent penetration. It was required to determine the velocity parameter of the projectile in the range from 58 m/s to 72 m/s, at which the penetration of the biological object occurs, with a confidence probability 0.95.

The primary data for the calculation of the minimum velocity of the thrown element x, sufficient to defeat the biological object, were the obtained velocity values and the result: penetration (P) or unbroken (U), for example, given in the table 3.4.3.

Table 3.4.3 — **Experimental data for determination of stability characteristics of biological material**

Speed, m/s	**Result**	**Number of breakouts**	**Number of unbroken**	**Accumulated number of unbroken**	**Accumulated number of breakouts**	**Total number of accumulated results**
46	U	0	1	10	0	10
49	U	0	1	9	0	9
54	U	0	1	8	0	8
56	U	0	1	7	0	7
57	U	0	1	6	0	6
58	U	0	1	5	0	5
65	P	1	0	4	1	5
68	U	0	1	4	1	5
72	P	1	0	2	3	5
73	P	0	1	3	2	5
76	P	1	0	2	3	5
79	P	1	0	2	4	6
80	P	0	1	2	4	6
83	P	1	0	1	5	6
84	P	1	0	1	6	7
85	P	0	1	1	6	7
90	P	1	0	0	7	7

The results of the experimental shooting are shown in the diagram (figure 3.4.6).

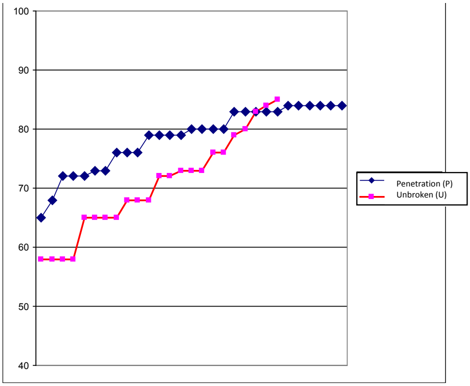


Figure 3.4.6 — **Experimental firing data on biological material**

Due to the bulkiness and complexity, calculations of the velocity of the wounding projectile were carried out in MS Excel according to the methodology set out in the textbook “using MS Excel to analyze statistical data” [11, pp. 50–58]. The values obtained as a result of data processing are given in the table 3.4.4.

Table 3.4.4 — **The results of the experimental firing**

Experience number	**Bullet speed, m/s**
1	65
2	68
3	72
4	72
5	72
6	73
7	73
8	76
9	76
10	76
11	79
12	79
13	79
14	79
15	80
16	80

End of table 3.4.4

Experience number	Bullet speed, m/s
17	80
18	80
19	83
20	83
21	83
22	83
23	83
24	84
25	84
26	84
27	84
28	84
29	84
The arithmetic mean value of speed	**78.55**
Standard deviation	**5.32**
Confidence interval	**1.93**
Extreme value	**65.00**
Maximum deviation	**2.55**

The final result of determining the calculation of the minimum value of the velocity of the thrown element at the penetration of biological material: $x = (78.55 \pm 2)$ m/s, with a confidence probability $\alpha = 0.95$.

Then in accordance with the accepted formulas in forensic ballistics calculation of the specific kinetic energy of a single wounding projectile:

where E — the kinetic energy of the bullet (J);

$$E = \frac{mV^2}{2} = \frac{2.4 \cdot 10^{-3} \cdot 78.55}{2} = 7.4\ (J),$$

m — bullet weight (kg);

V — bullet speed (m/s).

The cross-sectional area of the bullet:

$$S = \frac{\pi D^2}{4} = \frac{3.14 \cdot 5.45^2}{4} = 23.32\ (mm^2),$$

where S — bullet cross-sectional area (mm^2);

$\pi = 3.14$ (constant);

D — the diameter of bullet (mm).

Specific kinetic energy of the bullet:

$$E_{spec.} = \frac{E}{S} = \frac{7.4}{23.32} = 0.32\ (J / mm^2),$$

where E_y — specific kinetic energy of the projectile (J/mm ^{2}).

Thus, the judgment is confirmed that the value (E_y), accepted in forensic ballistic examination equal to 0.5 J/mm^2, hould be reduced to a value of 0.35 J/mm^2.

Thus, the study conducted in this section of the work allows us to formulate the following conclusions:

1. For the purpose of establishing an objective value of the minimum striking capacity of cartridges (ammunition) used for shooting from small arms, a comprehensive study of the properties of the elements of the system “ammunition — weapon — target”. The following should be considered as deterministic conditions: a) the striking ability of the wounding projectile of the cartridge (ammunition) used for firing; b) the susceptibility and vulnerability of the biological target to the damaging factors of the wounding projectile; c) the type of hand-held small arms depending on the action of the loading mechanism and the number of charges-single-charge(multi-charge), automatic (non-automatic).

2. The level of minimum specific kinetic energy equal to 0.5 j/mm^2, established at the present time by the Method of forensic investigation of cartridges for hand-held small arms, establishing their suitability for shooting, as well as the Method of solving the issues of belonging of objects to hand-held small arms, their serviceability and suitability for shooting, is not fully justified.

3.5. Method of measurement of parameters of traces of details of manual small arms firearms on bullets and sleeves

The essence of any type of forensic examination, including forensic ballistic examination of cartridges (ammunition) used for shooting from small arms, is the application of various methods of scientific knowledge in their conduct. Cartridges (ammunition) are systems with many elements, their properties, connections and relationships. Cognition of the totality of these properties, connections and relations is the main task of scientific cognition in the framework of forensic ballistic examination of these objects.

The model of solving research problems of forensic science can be presented as a kind of program for obtaining new scientific knowledge and developing methods and means of cognitive activity; such a program should determine the system of methods and means of solving a specific problem [52, p. 84]. The process of studying the objects of expert research assumes the presence of a set of cognition methods that determine meaningful thinking, with which it comprehends the object as a complete system of some elements, properties and features [247, p. 54].

O. S. Bocharova and O. M. Dyatlov, supporting the opinion of R. S. Belkin, according to which the methods of criminology are a system consisting of General, General scientific and special methods [27, p. 24], rightly point out that none of these methods can be absolutized, since they are implemented in theory and in practice in the relationship; only their totality can ensure the achievement of the goals of forensic knowledge of the phenomena of objective reality [27].

The connection of forensic examination with natural, technical and humanitarian Sciences is a natural result of the development of scientific knowledge in the theory and practice of expert research; the level of development of methods and technical means of research of various Sciences, in turn, largely depends on the development of methods, means and techniques of forensic examination [3, p. 279]. A special place among the technical means is occupied by means, the basis of the functioning of which is based on non-destructive methods of studying the properties of objects; the need for priority use of them is confirmed by the practical activities of expert institutions.

One of the main methods of forensic examination is measurement. This method is used in all types of forensic examinations, including forensic ballistic examinations of cartridges (ammunition). By means of measurement qualitative methods are supplemented with exact quantitative characteristics, as a result of which the transition from observation to mathematical abstractions (models) is carried out, real signs and properties of the studied objects are revealed, their essence is known.

The practical need of expert institutions in the process of solving the problems of forensic ballistic examination of cartridges (ammunition) involves not only the establishment of similarities or differences of the objects of study, but also the definition of numerical expression, which subsequently allows to correlate the values under consideration on the basis of their quantitative indicators. The analysis of expert practice shows that the solution of problems in the framework of expert research of cartridges (ammunition) is impossible without the use of appropriate means of measurement. This applies to the solution of all types of tasks in the process of expert research of cartridges (ammunition) for hand-held small arms — identification, diagnostic, classification and situational.

The acceleration of scientific and technological progress, the emergence of new types of hand firearms, cartridges (ammunition) to it, which are the objects of research forensic ballistic examinations, predetermine the trend of a constant increase in the requirements to ensure the reliability of obtaining relevant measurement information in order to increase the validity and reliability of the conclusions of forensic ballistic examinations. At the same time, the practical activities of expert units also lead to certain requirements, sometimes mutually reinforcing: 1) achieving high accuracy of measurements of research objects; 2) reduction of time of measurements and terms of production of examinations; 3) reduction of material costs for the acquisition, operation and maintenance of measuring instruments [81; 84; 92; 216].

Development of new technical, and also improvement of available means and methods for the purpose of their effective application in the course of carrying out judicial examinations is now one of priority directions of development of criminalistic science. Creation and application of methods of forensic examination as applied science and practical expert activity are subject to uniform laws, which include: the emergence of methods of knowledge as a result of the development of basic knowledge; borrowing of methods of related Sciences as a consequence of integration processes in science and development of means of knowledge; determining influence on the formation of research methods of increasing needs of expert practice; situational dependence of the method choice; situational dependence of the method application; regularities that determine the use of a complex of methods of both scientific and practical knowledge [37].

True is the position of A. A. Exarchopulo, the essence of which is that the role of forensic science in the creation of appropriate technical means should be as follows:

identification of the practical need for a technical means;

study of the current state, achievements and opportunities of science and technology;

identification of shortcomings of existing technical means used in forensic practice;

establishment of the circle of objects under study;

definition of conditions of application of the corresponding technical means;

establishment of technical requirements to be met by the device (technical device);

indication of the exemptions established by normative legal acts for the use of certain technical means in criminal proceedings [296, p. 83–84].

The activities of expert units often solve problems associated with the establishment of a model of hand-held small arms, as well as a specific instance of hand-held small arms, from which the withdrawn bullet or cartridge case was fired. This need arises not only in the investigation of crimes in the Commission of which hand-held firearms were used (murder, causing serious bodily harm, robbery, hooliganism), but also other crimes, in particular those related to illegal hunting. The above is relevant for forensic activities in the Republic of Belarus.

In scientific publications related to the practice of forensic ballistic examinations in the Russian Federation, it is also indicated the need to determine the source of origin of hand-held small firearms in its homemade manufacture or alteration of parts of weapons, parts and mechanisms of signaling, barrel gas and hand-held small firearms of factory manufacture [94].

One of the main parameters that allow you to determine the model and a particular instance of a hand firearm, are the dimensional and angular characteristics of the traces of the display of its parts on the surfaces of bullets and cartridge cases (ammunition). Traces of parts of hand-held small arms, formed on the elements of the design of cartridges (ammunition) as a result of contact interaction, are due to the phenomena and processes occurring in the process of their interaction, which have a direct and indirect influence on the mechanism of trace formation.

The degree of severity of trace-mapping depends on a number of factors: the materials from which the trace-forming and trace-perceiving objects are made, their physical and chemical properties; temperature conditions; the presence of foreign substances in the place of contact; kinetic characteristics of interaction, etc. Thus, taking into account the speed of the moving parts of automatic hand-held firearms in the process of functioning, which is 5–15 m/s [54, p. 224], as well as a significant mass of the locking mechanism parts (bolt, bolt frame, their totality), favorable conditions are created for the formation of traces of parts of hand-held firearms on the design elements of cartridges (ammunition) in the process of loading, shot production, extraction and ejection.

The traces on bullets and cartridge cases (ammunition) display features that individualize the type, model and specific sample of hand-held firearms. These features are characterized by an individual set of features and are due to the technological features of the process of manufacturing parts of the corresponding sample of hand-held small arms, for firing from which the cartridge (ammunition) was used). When determining the model of hand-held small arms, from which the bullet is fired, the diameter of the bullet, the number of rifles displayed on it, the width and angle of their inclination relative to its longitudinal axis are measured.

A. V. Kokin considered the possibility of determining the source of origin and method of manufacture from the point of view of establishing the characteristics of the traces of the bore of hand held small arms on the fired bulletsIt is known that the dimensional characteristics of the width of the rifling fields of hand-held small firearms are determined by the design documentation and are for Mak — $4{,}5^{+0.2}$; pistols PSM, IZH-75 — $2^{+0.1}$; for gun Baikal-442 — $3^{+0.2}$ mm. In addition, the angle of inclination of the rifling fields is important, which depends on the size of the pitch of the rifling in the barrel channel. Have pistols Mak and Baikal-442 step rifling equals 260 ±20 mm, a corner the tilt fields rifling — 6°23'; pistols PSM and IZH-75 — 290±20 mm and 3°28' respectively. The pitch of rifling barrels of small-caliber weapons produced by "Izhevsk machine-building plant" — 420±10 mm, the angle of the rifling— 2°24'; weapons produced by "Izhevsk mechanical plant" — 400±10 мм и 2°31' respectively. These values are calculated on the basis of the necessary external ballistic parameters for each type of cartridges (ammunition) of foreign manufacture at the design stage. Thus, as indicated in the scientific literature, the value of the angle of inclination of the traces of rifling fields on bullets fired from homemade barrels should differ significantly from the values established by the technical documentation [94; 95, p. 63; 243].

Measurement of parameters of traces of details of manual small arms on cartridges (ammunition) and elements of their design at carrying out identification forensic ballistic examinations is an integral condition of definition of a type and a concrete copy of manual small arms, definition of a source of its origin (factory, handicraft, self-made), degree of wear of the elements of a design forming traces. The above field width of grooves of different samples of small firearms, and angles of the marks on the bullets vystelennyh cause increased accuracy requirements held within these examinations of measurements, their reliability and of reasonable sufficiency. This, in turn, predetermines the need to use in the process of identification of the model (specific instance) of a hand-held small-arms firearm technical means of measurement, allowing with the necessary accuracy, minimum time and material costs to obtain the information required during forensic ballistic examination.

Besides, in practice of diagnostic ballistic researches of traces of manual small arms on bullets and cartridges of cartridges (ammunition) while such parameter as height of roughnesses of a profile remains unclaimed. At the same time, as E. I. Stashenko points out, the height and depth of the tracks in the traces on the fired bullets reflect the qualitative state of the surface of the fields and rifling in the barrel channel of hand-held small arms. So, from trace-forming surfaces of little-worn trunks traces in traces on a surface of bullets in height and depth from 3×10^{-4} to 8×10^{-3} mm are formed; trunks of average wear — from 11×10^{-3} to 15×10^{-3} mm; at a shot from a trunk with considerable wear — from 2×10^{-2} mm and more [244, pp. 30–31].

One of the parameters, the measurement of which until now was a certain complexity, was also the height of the profile irregularities (microrelief) traces of the rifling fields of the barrel on the fired bullets. Measurement of heights of roughness of a profile of traces of a bore on the thrown element (bullet) could be made only by means of a double microscope Linnik (MIS-11) — the difficult opto-mechanical device which principle of operation is based on use of a method of a light section [99, pp. 211–212]. However, the absence of this device in expert institutions still does not allow the full use of this parameter in the production of forensic ballistic examinations.

In order for the measurement result to be considered valid and subsequently used as evidence, it must meet certain criteria, i.e. be obtained:

an appropriate subject with special skills to carry out the relevant types of measurements;

from the proper source of factual data, information constituting the content of the evidence;

from the proper source of factual data, information constituting the content of the evidence;

with the observance of the proper order of the procedural action performed to obtain evidence [260, pp. 160–161].

In relation to measurements, the accuracy (reliability) of the result is determined by the methodically correct performance and competently justified (from a metrological point of view) estimates of errors (uncertainties) of the results obtained, as well as compliance with the requirements of regulatory legal acts [219].

Measurements performed in the process of forensic ballistic examinations, due to the need to determine the geometric parameters of the objects under study. In our opinion, measurements in solving diagnostic problems consist of the following stages:

measurement of parameters of research objects;

analysis of measurement results of dimensional characteristics;

comparison of the obtained set of quantitative values with the parameters of the proposed objects of the selected group;

formulation of the conclusion about the assignment to a certain class.

In the solution of identification tasks specified algorithm is supplemented by the integrated evaluation of measurement results taking into account visual comparison shaped characteristics of the traces and their characteristics with traces of parts of small firearms in the experimental samples, as well as the subsequent formulation of conclusions about the identity.

As a result of measuring the true value of a physical quantity cannot be obtained, the main issue is the allowable value of error of the measurements, wherein the deviation of the actual value of the measured value from its true value allows to use the result to solve expert problems [74, pp. 7–8]. The reliability of the measurement results is achieved by increasing the number of measurements under the mandatory condition — ensuring the necessary accuracy.

For the study of weapons traces on bullets and cartridge cases of cartridges (ammunition) are mainly used two methods: a) from the photos of the tracks; b) directly on the specified objects by means of the instrumental and comparative microscopes available at the disposal of expert divisions [8; 12; 185; 283]. Universal measuring microscopes can provide maximum accuracy of measurement of linear and angular parameters of traces, but in the majority of expert divisions such devices are absent.

For simplification of procedure of carrying out identification research developments in the field of automation of the specified process, creation of software and hardware complexes with application of computer technologies are now conducted. The state Committee of forensic examinations of the Republic of Belarus is currently using automated identification ballistic system TAIS-040 produced by JSC "LDI-RUSPRIBOR" (St. Petersburg, Russian Federation) [285]. Despite high efficiency of application, the specified system is expensive in this connection, taking into account rather rare need for its use, its acquisition for regional and regional expert divisions both practically, and economically inexpedient.

According to A. A. Artyushin and A. P. Patskevich, due to the impossibility at this stage to fully automate the identification process, the partial automation of expert studies is practically applicable, which due to greater accessibility and flexibility can significantly simplify the process of forensic ballistic examination. The availability of these methods can be ensured by the use of non-specialized tools, and conventional equipment using a personal computer [8].

This approach was implemented by us in the measurement tool developed within the framework of the study [82], based on the correlation analysis of digital stereo images of traces of hand-held small arms on bullets and cartridges with the help of specialized software installed on a personal computer, using the appropriate measurement methodology

[82]. To implement the correlation method of measuring the parameters and heights of the profile of rifling traces on bullets, a software application in the object-oriented programming language C++, in the programming environment, is developed C++Builder.

The developed software was included in the created software and hardware complex "Ballistic measuring analyzer "(hereinafter-PAK "BIZAN"). In addition to personal computer running the developed software application, in the PAK "BIZAN" includes stereoscopic microscope MSP-1 (is in service with expert divisions of the State Committee of judicial examinations of the Republic of Belarus), the coordinate object table with prepareoperation (intended for deployment and movement of the object of study when receiving a stereo image), a dial gauge ICH-10 (to measure displacement of the object), a digital camera and a stage micrometer (for preliminary calibration) (figure 3.5.1) [84].

Figure 3.5.1 — **General view PAK "BIZAN" for measuring the parameters of traces on bullets and cartridges**

The principle of operation of the device for measuring linear and angular parameters, as well as the height of the profile (microrelief) traces is simplified shown in the functional diagram (figure 3.5.2). On the photodetector matrix (5) through the optical system of the microscope (4), the first digital image of the measured trace displayed on the surface of the object under study is formed. After formation of the first image by using the coordinate table of a microscope (microscopic unit (2)) the object of study moves through space in a horizontal plane at a distance L, then the formation of the second digital image. While using the application, only the first image from the stereo pair obtained during the photo shooting is displayed on the monitor screen.

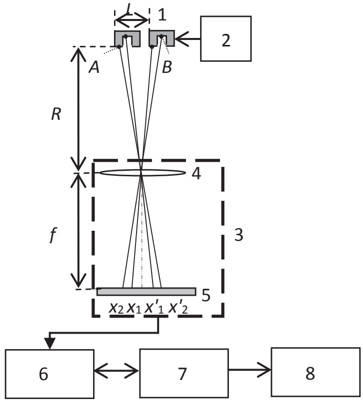


Figure 3.5.2 — **Functional diagram of the device for measuring the parameters of traces:**

1 — measured object, 2 — micro-displacement unit, 3 — digital microscope, 4 — optical microscope system, 5 — photodetector matrix, 6 — controller, 7 — processor, 8 — display unit

The obtained images are fed to the processor (7), where the profile heights, linear and angular dimensions are measured using the following algorithm.

The first image in the display unit (8) indicates the point of the object under study (scan window), to which you want to measure the distance. A scan window with similar coordinates is automatically generated in the second image. Next, the processor scans the first window relative to the second horizontally and vertically, and calculates the value of the two-dimensional normalized correlation function between the selected images in accordance with the expression:

$$R(\Delta x,\Delta y)=\frac{\sum\limits_{x,y}(I_1(x,y)-\bar{I}_1)(I_2(x+\Delta x,y+\Delta y)-\bar{I}_2)}{\sqrt{\sum\limits_{x,y}(I_1(x,y)-\bar{I}_1)^2\sum\limits_{x,y}(I_2(x+\Delta x,y+\Delta y)-\bar{I}_2)^2}},\ \bar{I}_n=\frac{\sum\limits_{x,y}I_n(x,y)}{x_{\max}y_{\max}},$$

where I_1 — the signal of the scan window of the first image; I_2 — the signal of the scan window of the second image; x_{max}, y_{max} — the size of the scanning window horizontally and vertically respectively; Δx, Δy — horizontal and vertical shift respectively, $\bar{I}_1, \bar{I}_2$ — the average values of the signal in the first and second scan window respectively; n — количество фотоснимков в стереопаре (n = 1, 2).

From the above expression, it follows that the scanning is carried out horizontally and vertically, which compensates for the possible deviation of the object movement from the horizontal line. The position of the maximum value of the normalized correlation function (1) determines the shift between the images $\Delta x_A = x'_1 - x_1$. The range R_A to the selected point of the object is determined from the expression:

$$R_A=\frac{f\cdot L}{\Delta x_A},$$

where L — moving the object under study horizontally, f — the focal length of the camera. Similarly, the distance R_B to the point B f the object having coordinates on the first and second images x_2 and x'_2 respectively is determined. According to the position of the maximum value of the normalized correlation function (1), the shift between the images $\Delta x_B = x'_2 - x_2$, is determined, and the distance RB to point B is determined from the expression:

$$R_B=\frac{f\cdot L}{\Delta x_B}.$$

The height of the surface profile of the object is determined by the difference of distances to the specified points of the object under study (point A and point B) $\Delta R = R_B - R_A$.

The device allows you to measure the linear dimensions of the individual features of the trace (microrelief) on the object under study between these points. It is carried out in the following way. Having determined the value of the distance to the i^{th} object of measurement R_i and the dimensions of this object (the distance between the specified points) on the photodetector matrix, the width of the measured object D_i and the height H_i are determined from the expressions:

$$H_i = \frac{R_i \cdot y_i}{f}, \; D_i = \frac{R_i \cdot x_i}{f},$$

where x_i, y_i — dimensions of the measured object (distance between points) on the photodetector matrix horizontally and vertically, respectively.

The system also measures the angle of inclination of the rifling marks on the bullets relative to its longitudinal axis. The expression for determining the slope angle of the cut trace α is as follows:

$$\alpha = arctg\left(\frac{X_2 - X_1}{Y_2 - Y_1}\right),$$

where X_1, Y_1 — coordinates on the photodetector matrix of the starting point of the trace cut, X_2, Y_2 — coordinates of the end point of the trail cut.

At the same time, it is not necessary to know the exact value of the distance between the sensitive elements of the photodetector matrix and the value of the focal length of the lens of the photography device, since these values can be determined during the calibration of the system according to the standard. Correlation image processing allows you to determine the position of the object on the matrix with an accuracy higher than one sensitive element (pixel) [82; 84; 92].

The high accuracy of the measurements is due to the increased requirements to their results imposed by both the Criminal Procedure Code of the Republic of Belarus [265] and technical normative legal acts aimed at ensuring the right to protect the legitimate interests of citizens from the negative consequences of unreliable results of measurements.

The accuracy of the measurements using the developed PAK "BIZAN" largely depends on the size of the photodetector matrix of the camera device. For example: the size of the photodetector matrix used in the measurement tool is 22.5×15 mm or 5472×3648 pixels, then the size of one pixel of the matrix will be:

$$n = \frac{x}{a} = \frac{22.5}{5472} = 4\times10^{-4}\,(mm),$$

where n — size of one matrix pixel (mm);

x — linear size of the matrix on one side (mm);

a — number of pixels on the selected side.

Thus, the deviation of the measured parameters from their true values will be no more than 4×10^{-4} mm, which in accordance with the provisions of GOST of the Republic of Belarus 8.051-81 "State System for Ensuring the Unity of Measurements. Errors Allowed When Measuring Linear Dimensions up to 500 mm" it will allow to measure the dimensional characteristics of traces up to the fifth quality (class) of accuracy (when measuring linear dimensions up to 10 mm) [49, p. 2].

In the Method, the identification of rifled guns on the trail on the bullets [164] and Methods of identification of firearms marks on cartridge cases [165] requirements to the accuracy of the measuring equipment is not installed. According to the data given in the forensic literature on the parameters of traces of hand-held firearms on the fired bullets, the difference between the upper and lower value of the angle of inclination of the rifling can vary within 0°10'– 1°30', the width of the trace of the field of rifling — from 0.1 mm to 1.5 mm [121].

In the works of I. A. Dvoryansky and V. V. Filippov, it is indicated that when measuring traces of hand-held small arms on bullets and cartridges, the values of 0.01–0.1 mm — for linear dimensions and 0°10'– 0°20' — for angular values [59; 274, pp. 10–17] are sufficiently accurate, similar parameters are given in the work of A. V. Kokin [95, p. 217]. B. M. Komarinets believes that when measuring the parameters of traces, the minimum accuracy should be when measuring the width of the traces of the rifling fields — 0.05 mm, when measuring the angle of inclination — 0°10' [99, p. 204].

Thus, the permissible error of measurements in the production of such measurements, used in the practice of expert units during identification forensic ballistic examinations, significantly exceeds the limit of error developed by us PAK "BIZAN".

The interface of the software application for measuring linear and angular characteristics of the PAK "BIZAN" includes the following user elements: information line; general tools (open, save, clear); functional tools (selection, moving, deleting), calibration, adjustment of display and measurement parameters; switching of view mode: enable / disable linear measurement, enable / disable angular measurement; enable / disable linear and angular measurement, active window (figure 3.5.3).

After activation of the software application the input of a photo image of the surface area of the object with the measured trace and calibration of the measuring instrument are carried out.

The calibration process is carried out before the measurement of each new object of study. The holder of the coordinate table of the microscope is fixed to the object of study and using the ocular ruler microscope produces a measurement of the distance between the two selected object points, for example between "fighting" (mark a) and "single" faces (mark B) trace of the thread (figure 3.5.4). In the software application select the tool enable the measurement of linear values (length) and connecting these points in the active window of the software application, specify in the box for the first line measured with a microscope distance, then press the tool "calibrate". In the active window of the software application, the initial value of the dimension characteristic must change to the value entered during calibration. This completes the calibration process.

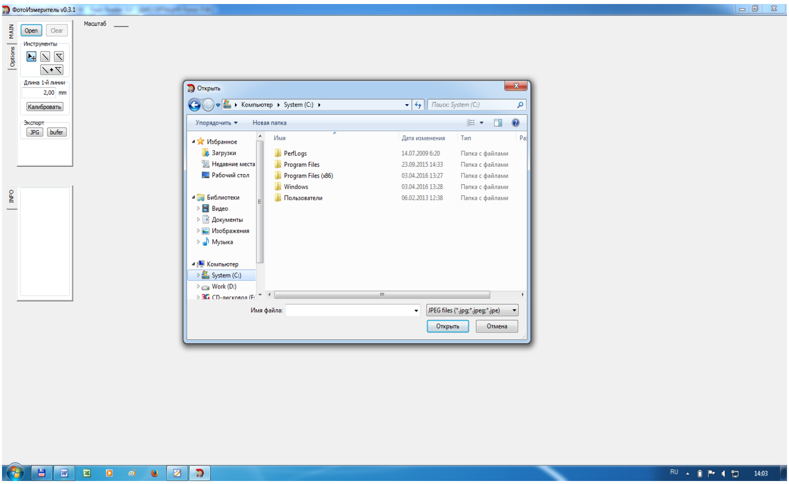


Figure 3.5.3 — **The interface of the software application PAK "BIZAN" when you activate the tab "Open"**

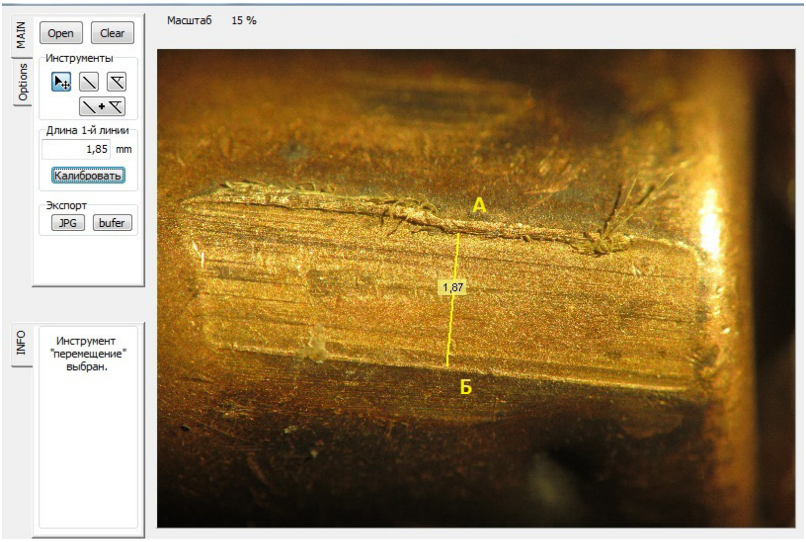


Figure 3.5.4 — **The view of the active window of the software application after loading the investigated image of the trace cutting the bore on the surface of the bullet and calibration**

Figure 3.5.5 illustrates an example of the measuring system during the measurement of linear and angular parameters of the traces of the rifling fields displayed on the bullet from a digital photo image. It should be borne in mind that the "primary" traces on the photograph of the fired bullet should be parallel to the bottom edge of the active window of the software application (this is due to the algorithm of the software application).

After the calibration of the system, the user, including the measurement modes of the necessary parameters of the object under study, makes a measurement in the active window of the software application using the mouse manipulator (left and right keys) by laying conditional segments in the "control" points of the image. Depending on the required parameter the corresponding linear and angular parameters are displayed next to the segments in rectangles with a yellow background. If necessary, the measuring periods can be remove and take the measurement again according to the above algorithm.

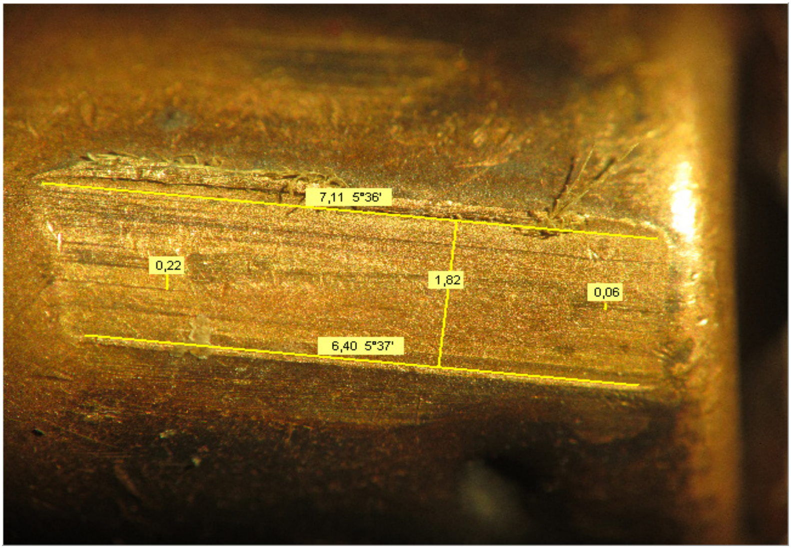


Figure 3.5.5 — **View of the results of measurement of linear and angular parameters, the trace of the cut field of the bore on the bullet cartridge 7,62×25, fired from a TT pistol** (the distances in the figure are in millimeters, the angles in degrees and minutes)

After the calibration of the system, the user, including the measurement modes of the necessary parameters of the object under study, makes a measurement in the active window of the software application using the mouse manipulator (left and right keys) by laying conditional segments in the "control" points of the image. Depending on the required parameter the corresponding linear and angular parameters are displayed next to the segments in rectangles with a yellow background. If necessary, the measuring periods can be remove and take the measurement again according to the above algorithm.

Figures on a yellow background show the distances between the selected points in the measured trace in millimeters and the angles of inclination of the traces from the "combat" and "idle" faces of the rifling to the longitudinal axis of the bullet in degrees. For example, the width of the cut mark on the bullet is 1.82 mm, and the length of the marks from the "combat" and "idle" faces of the cut is 7.11 mm and 6.40 mm, respectively. The angles of inclination of these traces relative to the longitudinal axis of the bullet are 5°36' and 5°37', respectively.

Figure 3.5.5 also shows the results of measuring the distances between the individual grooves displayed in the secondary cut trace of the bore, the distance between which is 220 microns and 60 microns, respectively.

In addition to the possibility of making measurements on shot bullets, this measuring system is able to measure the linear and angular parameters of the traces on the sleeves. Figures 3.5.6 and 3.5.7 show the results of measurements of linear and angular parameters of traces of weapons after the production of a shot on a cartridge sleeve 9×18Mak, fired from a pistol IZH-70-18ME. Thus, the illustrative material confirms the conclusion that the system provides sufficient accuracy of measurements with ease of use without the use of expensive and complex equipment.

Figure 3.5.6 — **View of the measurement results of linear parameters, traces striker striker, reflector, shutter dosylatelya cartridge sleeve 9×18Mak, shot from a pistol IZH-70-18ME**

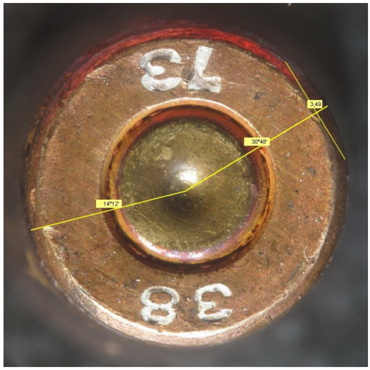


Figure 3.5.7 — **View of the measurement results of linear and angular parameters, the relative position of the ejector trace and the reflector trace on the cartridge sleeve 9×18Mak, fired from the pistol IZH-70-18ME**

By the difference of distances to the points of the object, you can determine the depth of the profile of the cut trace on the bullet at a certain point (figure 3.5.8). Thus, for the point located at the top of the image at a distance of R = 15.20 mm, the height of the trace profile is 390 microns R = 15.20 mm, the height of the trace profile is 390 microns (ΔR = 15.20–14.81 = 0.39 mm), nd for the profile point at a distance of R = 14.38 mm in the lower part of the trace image — 330 microns (ΔR = 14.38–14.05 = 0.33 mm).

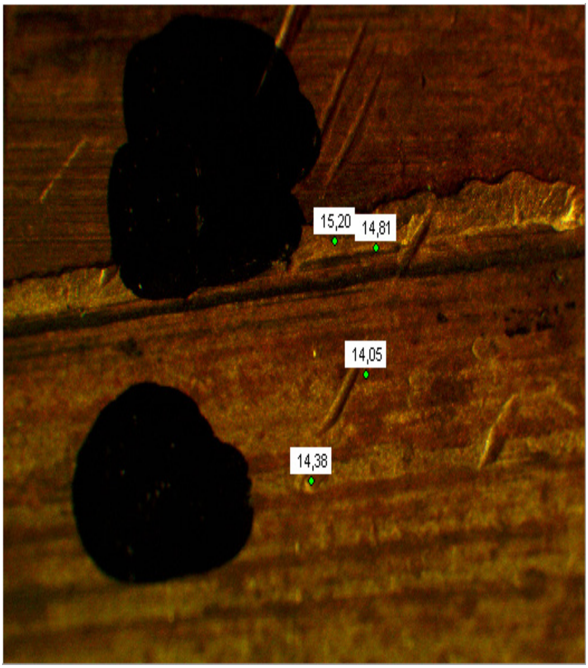


Figure 3.5.8 — **The results of measuring the heights of the irregularities of the profile section of the trace fields of the rifling of the bore on the bullet cartridge 7,62×25 by a round fired from a pistol TT**

Images of traces on bullets and cartridges with dimensional characteristics the software application allows you to save to the clipboard of the personal computer on which the software application is installed, or as a separate file in the format (.jpg) for subsequent use in the preparation of illustrative material expert opinion. The positive quality of the developed software application, which is part of the PAK "BIZAN", is that it does not require installation on the hard disk of the computer when working with portable media (memory cards), thereby providing mobility of use, including inspections of accident sites.

The results obtained during the testing of this device indicate the high efficiency of its work in solving identification and diagnostic tasks in the framework of forensic ballistic examinations of cartridges (ammunition).

Thus, the study conducted in this section allows us to formulate the following conclusions:

1. Use of cartridges (ammunition), elements of their design of technical means of measurement during forensic ballistic examinations is caused by process of scientific knowledge and practical need of use, along with methods of a qualitative assessment, quantitative assessment of essence and properties of objects of research of their set which establishment allows to increase validity of the received results and reliability of conclusions at carrying out forensic ballistic research.

2. Development of new and modernization of existing technical means of expert divisions as a result of their partial modernization are capable to provide the minimum material expenses at introduction of the developed PAK "BIZAN" in activity of expert divisions, having provided a certain economic effect.

3. Application of the developed PAK "BIZAN" for measurement of linear and angular parameters, heights of irregularities of a profile of objects of research at carrying out forensic ballistic examination of cartridges (ammunition) allows to receive measuring information of necessary accuracy and reliability, increases representativeness of quantitative indicators of the measured parameters. In addition, it will contribute to increasing the efficiency of the use of the equipment available in expert laboratories due to the fuller use of its functional capabilities, reducing time-consuming costs in solving all types of tasks of forensic ballistic examination of cartridges (ammunition) and hand-held small arms, in which they are used for shooting, and thereby reducing the cost of examinations and research.

3.6. Methods of forensic investigation of cartridges for hand-held small arms, establishing their suitability for shooting

Development science and technology, the emergence of new and upgrading the existing patrons (ammunition), used for called the shots from manual small arms firearms, determine the application of integrated approach to studying their properties with goal categorization ammunition and definitions suitability their for called the shots with the help appropriate methods and technical means in order, defined appropriate techniques.

Cartridges (ammunition) for hand-held small arms are the most common object of research forensic ballistic examinations. As already mentioned, in the total number of this type of expertise performed by the main Department of Forensic Examinations of the Central office of the State Committee of Forensic Examinations of the Republic of Belarus in 2017, cartridges were the objects of research in almost half of cases. In addition, according to the results of the earlier survey of employees of the State Committee of forensic examinations of the Republic of Belarus, the study received, along with factory cartridges (ammunition) and cartridges made by homemade means, as well as cartridges re-equipped with elements of cartridges of factory manufacture.

When carrying out these studies, experts established the fact that cartridges belong to the category “ammunition”, and also determined the state of their suitability for firing, since these properties are the determining criteria for the qualification of illegal acts.

Complication and expansion of special knowledge, necessity of the decision of the problems arising in expert practice, including at carrying out examination of cartridges (ammunition), objectively cause necessity of the address to exact, reliable and strict methods of research: mathematical, physical, cybernetic, etc. which efficiency is confirmed by concrete researches. At the same time in forensic science it is considered that only an integrative approach is able to achieve the desired result. From the information point of view, the methods should contain prescriptions that ensure the most optimal performance of a particular type of cognitive and practical activity [25, p. 62; 42, p. 186]. In the expert methodology, modern achievements of science and technology should be fully used in order to increase the representativeness of the conducted research, so that the results of the conducted expert research are available for perception by a person who does not have special knowledge [61].

In accordance with the definition contained in the dictionary and reference literature, the methodology of forensic examination is understood as a system of methods (techniques, technical means) used in the study of objects of forensic examination to establish facts relating to the subject of a certain kind, type and subspecies of forensic examination [233, p. 43].

In the literature on the theory of forensic examination contains a number of definitions of the term "technique", developed in the process of formation of this science. Thus, A. I. Vinberg and A. R. Shlyakhov proposed the following definition" the methodology of expert research is a system of scientifically based methods, techniques and technical means (devices, apparatus, devices), ordered and focused on the study of specific objects and solving issues related to the subject of expertise" [36]. D. Ya. Mirsky expert methodology is defined as a detailed program of study by a person with special knowledge, the properties of certain objects to establish the circumstances of evidence-based value, the content of which is the use in a certain sequence developed for this purpose, the system of research methods [169]. M. E. Bondar in the work "Expert technique as one of the main categories of the General theory and practice of forensic examination" defines the term as a program for solving an expert problem, consisting of successive practical and mental operations aimed at knowing the properties and connections of the objects under study and involving the use of a system of certain methods and means of research [24].

It seems that it is the systematic process of expert research allows you to objectively establish the properties of the studied object as a whole, and separately from each other. In this regard, we share the view of E. P. Orekhova that the understanding of the techniques of expert research through the category "system" means the purposefulness and orderliness of the use of methods (techniques, tools), when interconnected and forming a certain integrity methods are used in the established order (sequence) that depends on the expert tasks as well as specific conditions of implementation studies [188, p. 94].

As A. M. Mikhailov notes, the technique acts as a "technique" of a certain method, which was formed due to the application of the method to the study of a certain object. This scientist points out that the method, in contrast to the method, is always instrumental, always associated with a certain range of tasks, i.e. acts as a means of solving them. At the same time, the degree of formalization of the method in comparison with the method is much higher: many methods are algorithmized sequences of actions [170, p. 314].

In our opinion, the most complete and comprehensive content of the term "methodology of expert research" is disclosed in the definition proposed by T. V. Averyanova. Under this term, the author understands the system of prescriptions (categorical or alternative) for the choice and application in a certain sequence and in certain existing or created conditions of methods and means of solving the expert problem [3, p. 290]. This approach meets the practical activities of the expert units of the State Committee of forensic examinations of the Republic of Belarus.

The theoretical provisions concerning the methods of forensic investigation of cartridges used for shooting from small-arms firearms, the issues of their classification as ammunition, the establishment of suitability for shooting, to a certain extent covered in the scientific and methodological literature [31; 102; 112; 232; 248; 303]. At the same time, the continuous process of technical improvement of hand-held firearms, the development of scientific ideas and approaches to their design, combat and operational properties, the emergence of new complexes "weapon — cartridge" objectively entail the need to improve existing and develop new methods of expert research of cartridges (ammunition) used for shooting from hand-held firearms. In the legal literature it is noted that the goal of optimizing the structure of applied legal knowledge is especially relevant at the present time, when it is understood not as an abstract category, but as an intellectual tool focused on the practical needs of jurisprudence [25, p. 3].

In the framework of the study, the author, together with the staff of the State Committee of Forensic Examinations of the Republic of Belarus, developed a Method of Forensic Examination of cartridges for hand-held small arms, establishing their suitability for shooting (hereinafter — Methodology), aimed at improving the forensic study of cartridges, eliminating identified in the process of practical application of the previously existing methods of forensic research of cartridges inaccuracies of certain provisions, including taking into account modern theoretical approaches to the issues of forensic research of cartridges (ammunition) of small arms and firearms.

During the period of practical application Of the methodology of forensic research of cartridges in the activities of expert units, methodological omissions were identified: the lack of a clear structure, which led to inconsistency of the stated provisions, incomplete accounting of the features of the expert study of re-dressed and homemade cartridges. These and a number of other shortcomings and necessitated the development of a draft new Methodology.

Structurally, the Methodology includes the following sections: "Key terms and definitions, Tasks and examination questions to be solved by her conduct", the "examination Objects", "Entity methods", "Criteria for the assignment of cartridges to category of ammunition, small firearms", "the suitability of the cartridge for firing", "a Sequence of actions expert", "Specifics of the study a large number of cartridges, Equipment, tools and materials required for examination (research), Literature".

Within the framework of the issues considered in this section it seems reasonable to briefly disclose the content of some sections of the Methodology.

So, the importance of the "Basic terms and definitions", under Methodology, in contrast to previously existing methods of forensic examination of the cartridges is determined by the fact that until recently in the manufacture it is judicial-ballistic examinations used the terminology contained in the various technical, forensic, regulatory and other sources that, in practice, in certain cases, led to ambiguous understanding of the properties of the objects, the lack of unity in the order of their expert research, the findings of [4; 73; 96; 152; 133; 134; 145; 224]. The relevance of the question concerning the terms and their definitions used in the production of examinations of cartridges (ammunition) is also confirmed by the results of our survey of employees of the State Committee of Forensic Examinations of the Republic of Belarus.

To resolve the outlined problem, a separate section "Basic terms and definitions" is included in the Methodology, which fixes the definitions of common terms used in the production of forensic ballistic examinations of cartridges (ammunition). These terms and their definitions are in accordance with the provisions of GOST 28653-90 "Small Arms. Terms and definitions" [190], which eliminates the different understanding of the described processes and phenomena in order to achieve a uniform application in the practical activities of the units of the State Committee of forensic examinations of the Republic of Belarus. In addition, taking into account the established expert practice of forensic ballistic examinations of cartridges (ammunition), the provisions of this section of the Methodology determine the procedure for specifying the names of different cartridges in accordance with C. I. P. standards. The permanent International Commission for the testing of hand-held firearms (Fr. Commission internationale permanente pour l'épreuve des armes à feu portatives) [200; 306].

Thus, in accordance with the provisions of the European standard C. I. P., the name of the cartridge indicates its caliber, the length of the sleeve in millimeters, as well as the presence of a protruding flange (Rant). Less often, the type of hand-held small arms, the purpose of the cartridge and the weight of the bullet are indicated.

Based on discussed in section 3.1 of this Chapter basic expert tasks when carrying out it is judicial-ballistic examination of the cartridges (ammunition), it is assumed that by the practical implementation of the methodology contained in the regulations are solved by two groups of tasks: classification (of the object to the category of ammunition); diagnostic (regarding the method of manufacture, the origin of the object of examination of the functional (target) purpose, and establishing its suitability for hitting the target in the shooting). The solution of the specified tasks by application of requirements of a Technique allows to optimize process of carrying out forensic ballistic examinations of cartridges (ammunition), and to bodies of criminal prosecution, court, other interested persons — to understand its course and the received results, provides reliability of the conclusion of the expert.

Thus, the developed Technique belongs to a typical type of techniques and is intended for the solution of standard expert tasks, expresses the generalized practical experience of carrying out examinations of cartridges (ammunition) by experts of the State Committee of Judicial Examinations of the Republic of Belarus.

Based on the list of tasks given in the Methodology, the expert can formulate the following conclusions based on the results of the expert study of the objects submitted for examination:

about the type (type, caliber, sample) of the cartridge presented for research;

about reference (non-reference) of the cartridge of factory production to category of ammunition;

about accessory of cartridges of factory production to a certain group (fighting, sports, hunting, traumatic, gas, signal, educational, idle, etc.);

about the type (type, sample, caliber) of the weapon in which this cartridge is intended (or can be used) for firing.

According to point 4 of the earlier operating Technique of criminalistic research of cartridges accessory of cartridges to ammunition of small firearms was established on presence at cartridges of set of two groups of signs: 1) design features due to their intended purpose (includes the use of explosives (gunpowder), multicomponent and disposable); 2) signs that determine the serviceability and suitability of the object under study (cartridge) to defeat the target [163].

To establish compliance of the cartridge to the first group of characteristics the expert it was necessary to determine the presence in its design of necessary structural elements — methane elements (bullets, shot, buckshot), cartridge cases, primer (device trigger), the propellant charge, as well as set the similarity of the external structure of the cartridge with the samples of ammunition, which is ammunition for specific models of small firearms factory and handicraft production.

The presence of the cartridge features of the second group (characterizing the serviceability and suitability of the projectile element of the cartridge (ammunition) to defeat the target) was confirmed by establishing compliance with the technical security of the investigated cartridge to defeat the target. In addition, in some cases it was necessary to establish the sufficiency of the energy characteristics of the projectile (bullets, shot, buckshot) according to the results of experimental shooting.

The provisions of the developed Methodology, establishing the procedure for the study of cartridges (ammunition) improvised (or reequipped with the use of structural elements of ammunition (ammunition) factory production), the basis of foreign experience, according to which the expert review process data objects is divided into two main stages:

analytical, which establishes the presence of all structural elements of the cartridge (throwing element, propellant charge, initiation device, sleeve). The presence of these structural elements is determined by external visual inspection, technical means of non-destructive principle of action or (in exceptional cases) by partial dismantling of the object of study;

experimental, aimed at determining the suitability of the cartridge for shooting and evaluation of the striking ability of the thrown element — the value of the specific kinetic energy, on the basis of which the final conclusion is formulated. Thus determination of suitability of the self-made (peresnaryazhennogo) cartridge to firing is a part of research concerning its reference to category of ammunition [303, pp. 86–87].

Taking into account the characteristics defined in the framework of this work, characterizing the category "munition" in its forensic meaning, the following main criteria for classifying the object under study to this category were included in the Methodology:

1. Multicomponency is a structural amalgamation of different purpose of elements in a single device.

Multicomponency of cartridges (ammunition) used for firing from small arms, is established by the presence of a complex of necessary structural elements providing defeat of the purpose at distance by the thrown element actuated by energy of powder gases or other explosive as a result of a shot. This criterion assumes mandatory the availability of in design patron basic elements: propellant charge; metaemogo element of (single either multiple); means initiating; thimbles, through which enumerated components unite in a single device [112; 202].

If one of these four elements is missing from the factory-made cartridge submitted for study, then this cartridge does not meet the criterion of multicomponency and, accordingly, does not belong to the category of ammunition for hand-held small arms. However, in some samples of ammunition, both factory and homemade (for example, the cartridge Flaubert, self-made ammo, made of capsules-igniters of closed type) [112; 202; 305], the propellant as a separate subassembly can be absent, it is the role of pyrotechnic composition, placed in the sleeve or the means of initiation. The decisive criterion for the classification of cartridges of this design is the category of munitions is to achieve a welded element of the minimum level of lethality $E_{spec.} \geq 0{,}5$ J/mm^2 in experimental ejection of the cartridge (ammunition) by measuring the energy characteristics.

2. *Single use* — the property of the cartridge, consisting in the possibility of its single use for the intended purpose.

Single use implies the impossibility of reuse for the intended purpose of a particular instance of the cartridge without the use of special techniques to restore its original properties.

3. *Intended for destruction of the purpose* — property of the ammunition caused by ability of the thrown element as a result of firing from manual small arms firearms to cause the penetrating injuries dangerous to life and health of the person.

This criterion corresponds to cartridges (ammunition) of factory manufacture, equipped with a single or multiple throwing element (metal bullet, shot, buckshot) and intended for shooting in rifled or smoothbore firearms.

Intended for destruction of the purpose of cartridges of factory production is defined on similarity of the presented objects with samples of the cartridges which are ammunition for specific models of firearms. Thus compliance of an external structure (the form, the sizes, weight, marking designations, a design as a whole and its separate components) to analogs-samples of a certain type, type, caliber of the cartridges which are ammunition to manual small arms is established.

The theory of judicial-ballistic examination and practical expert activity confirm the validity of the assertion that the inclusion of ammunition factory manufacturing ammunition requires only the existence of the necessary elements in the design, the serviceability and suitability for use for the intended purpose (group of symptoms) is not the defining criterion, as cartridges (ammunition) of factory production according to the functional (target) appointment are intended for defeat of the purpose as a result of firing from manual small arms of firearms. The energy characteristics of the thrown element of such cartridges (ammunition) are many times higher than the amount of kinetic energy required to defeat a person [31, pp. 53–55; 231; 232, pp. 17–20; 267, pp. 16–17; 303, p. 80].

The analysis of law enforcement and expert practice confirms the need for mandatory experimental firing with measurement of energy characteristics of the thrown element of cartridges (ammunition) of homemade manufacture (or reloaded).

Based on the above, determine the energy characteristics of a welded cartridge element artisanal, improvised, as well as ammunition, to independently reequipped with the use of structural elements of ammunition (ammunition) factory made, for the purpose of assignment to categories. Measurement of energy characteristics of the thrown element shall be carried out with use of devices of measurement of speed of flight of the thrown element included in the State register of measuring instruments and passed the established metrological verification [125; 126];

4. One of the criteria for identification of ammunition improvised (reequipped with the use of ammo items factory manufacturing) is also the suitability of the cartridge to fire the cartridge's status, which provides the possibility of firing from a particular sample of the firearms presented on the study either a similar caliber barrel and (or) the parameters of the chamber.

The Methodology contains a provision according to which the suitability of the ammunition for firing is set by the peer experiment (pilot shooting) using weapons designed to fire cartridges of this type (type, calibre), or weapons-substitute. In case of absence in full-scale collection of the expert division of the weapon of the corresponding caliber for the decision of a question of suitability of the cartridge of factory production for firing use of the special equipment — the device of check of cartridges on operation is allowed. At the same time, it is clearly stipulated that the use of such a device is possible only when deciding on the suitability for firing factory-made cartridges that do not have significant external defects, the list of which is determined by the Methodology.

Thus, the essence of the developed Methodology is to regulate the actions of the expert associated with the establishment of:

compliance of a complex of signs of the investigated cartridges to a complex of the signs inherent in ammunition to manual small arms;

suitability of the cartridge (ammunition) for firing.

In contrast To the methodology of forensic investigation of cartridges, the provision on the possibility of solving such a problem as determining the serviceability of cartridges (ammunition) is excluded, since this does not correspond to the goals of forensic ballistic research of these objects. This approach is based on the provision of sub-paragraph 2.1 of paragraph 2 of GOST 27.002-89 "Reliability in technology. Basic concept. Terms and definitions", according to which the term "serviceability" is defined as the state of the object of factory production, in which it meets all the requirements of normative-technical and (or) design documentation, and, conversely, the faulty state is understood as the state of the object of industrial production, in which it does not meet at least one of the requirements of normative-technical and (or) design (design) documentation [174, pp. 2–3].

Thus, provisions of the Methodology cannot be used to assess the health of the cartridge (ammunition) improvised, as faulty as the state of the object of study is established in the analysis of the compliance with the requirements of normative-technical documentation of cartridges (ammunition) factory workmanship and does not cover improvised (reequipped) cartridges, requires the use of appropriate measuring equipment and tools. Such condition of the investigated cartridge, as serviceability, characterizes the investigated object from the point of view of possibility of performance by it of the functions and corresponds in General to provisions of GOST 27.002-89 “Reliability in equipment. Basic concept. Terms and definitions” [18; 174, pp. 2–3; 52].

The specified allows to draw a conclusion about two forms of suitability of the cartridge for firing (possibility of defeat of the purpose as a result of implementation of shots or a shot from small firearms in aggregate with preparatory, accompanying and finishing their receptions and processes): it is suitable for firing; it is unsuitable for firing.

The term “suitability” in this case characterizes the state of the investigated cartridge (ammunition), in which it is able to perform certain functions, and the properties identified in the process of research — to meet the criteria established by the Methodology (in particular, to provide the value of the specific kinetic energy of the thrown element when fired ($E_{spec.} \geq 0{,}5$ J/mm^2). The use of the term “suitability” in the production of forensic ballistic examinations of cartridges (ammunition) is due to the need to study the condition not only of factory-made objects, but also homemade, as well as re-dressed homemade cartridges using elements of cartridges (ammunition) of factory manufacture.

The provisions of the Methodology establish a clear sequence (algorithm) for solving classification and diagnostic problems in the examination of cartridges (ammunition) used for shooting from small arms. The envisaged procedure is based on the principle of consistency, since the process of any expert study (forensic examination) consists of a number of interrelated stages, the strict sequence of which largely determines the logic and validity of the findings, their consistency. In addition, this procedure will significantly ensure the assessment of the reliability of the findings of the criminal prosecution and the court, other interested parties.

It should be noted that currently there are two main approaches to determining the stages of expert research in the overall structure of the expert methodology. Proponents of the first approach (Russian scientists R. S. Belkin, T. V. Averyanova, E. R. Rossinskaya and A. R. Shlyakhov) distinguish the following stages: 1) preparatory stage (preliminary study); 2) analytical stage (separate study); 3) comparative study; 4) evaluation of research results and formulation of conclusions [3, p. 428; 291, p. 101].

Representatives of the second approach (Belarusian authors I. A. Anishchenko, E. Yu. Goroshko, N. V. Efremenko) refer to the main stages of expert research: 1) preliminary study; 2) detailed study; 3) evaluation of research results and formulation of conclusions; 4) registration of examination materials [47, p. 186; 256, p. 138]. The main difference between this position is the inclusion of comparative research and expert experiment in the stage of detailed research in connection with which it is more preferable, since it reflects the algorithm of the process of expert research used in practice. At the same time allocation of registration of materials of examination as a separate stage has debatable character as the specified process in essence is procedure of material fixing of a course and results of expert research which has basically organizational and technical character.

Nevertheless, the first (classical) approach to its construction was used in the development of the Methodology. The sequence of actions of the expert at these stages has no fundamental differences from the sequence, which was provided for by the previously existing methodology of forensic investigation of cartridges.

At the stage of preliminary study, the expert, after reviewing the content of order for inspection, packing inspection and photography examines the study of the objects on the list specified in the resolution.

At the stage of detailed research, photography of objects of examination (research) is carried out, technical and other characteristics of the object of research are determined: cartridge design (state of visible structural elements); General weight and size characteristics (total length, mass); type and type of the thrown element, its dimensional characteristics, method of attachment in the sleeve, color marking. If necessary and there are markings on the object, their decoding is carried out. In addition, the expert establishes the method of manufacturing the object of study, defects on the outer surfaces of the structural elements, the presence of traces indicating a possible homemade equipment or re-loading of cartridges of factory manufacture.

Upon completion of these actions, the expert may formulate the following preliminary conclusions:

about a method of production of object (factory, self-made, self-made (re-dressed) with use of elements of the cartridge of factory production);

about presence (absence) at the investigated cartridge of the signs characteristic of ammunition of small arms (smooth-bore or rifled);

about availability at the cartridge of the signs characteristic for traumatic, gas, signal, idle, auxiliary cartridges, the cartridges which are not intended for defeat of the purpose;

about presence on elements of the cartridge of external defects, etc.

With regard to the comparative stage of the study, the provisions of the Methodology provides a comparison of the findings in separate studies of technical characteristics and design features of the test cartridge (elements) with technical characteristics and design features of cartridges of different kind (model, caliber), their elements specified in the reference literature available in the field collections, and other allowable sources of information, the establishment of the identity of elements of complex structural elements known species, specimens, calibers of cartridges which are ammunition to manual small arms firearms, or establishment of similarity of a design (for cartridges of self-made production or overvoltaged).

One of key stages expert research patrons (ammunition) and definitions suitability their for called the shots, as already pointed out, is conducting expert experiment (experimental called the shots). With the help experiment in forensic-ballistic expertise tested a certain set of hypotheses, expedited fundamental significance under addressing expert tasks. On this occasion, R. S. Belkin notes that the experiment, being applied in the process of research, allows us to empirically verify the correctness of ideas about a particular fact or establish new ones [17, p. 10]. In relation to the situation in which during the experimental firing of the shot did not occur, the Methodology establishes the provision that, if necessary, the expert can dismantle the cartridge submitted for study and determine the cause of failure.

The experimental firing is necessarily preceded by the study of the external condition of the cartridges in order to detect defects, as well as the suitability for firing of hand-held small arms used for its conduct. In particular, defects such as thickening of the lubricant and contamination of the channel under the striker, small output of the striker, its excessive sharpness, blunting, nicks on its surface, contribute to an increase in the probability of misfires in the production of experimental shooting. For the machine gun (AKM), machine gun (PKK) and hunting rifled hand small arms (carbines "Boar", "Saiga"), made on their basis, the output of the striker striker is from 1.4 to 1.52 mm; for the rifle (carbine) Mosin design — rom 1.9 mm to 2.41 mm; for Makarov pistol — from 1.1 to 1.35 mm. The size of the filling of the striker in the manual small arms of domestic production (combat, service and civil) is from 0.6 to 0.9 mm.

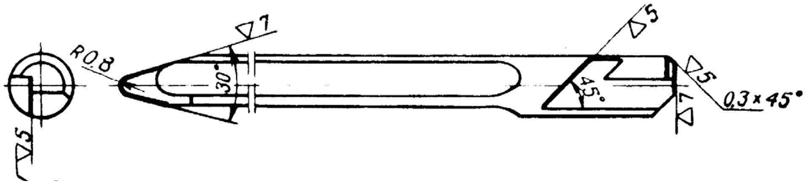


Figure 3.6.1 — **Repair drawing of 9-mm Makarov pistol drummer**

In case of absence of defects in cartridges of factory production ammunition and improvised equipment intended for firing from smooth-bore manual shooting ognestrela weapons, as well as the lack of the necessary caliber weapons in collections of weapons when deciding about the suitability of these cartridges for firing allowed the use of special equipment, e. g. devices to test bullets caliber 4.5–11.43 and hunting ammo to 12 gauge for suitability to the shooting.

If during experimental firing shots followed after the first blows of the striker, misfires were not observed, the conclusion about the suitability of cartridges for firing is formulated. If in the course of experimental firing cartridge failed, the examiner is required to re-attempt firing the cartridge, wherein the Method is recommended to use another instance of the weapon (the barrel multi-barrel guns). To complete the experiment should be carried out at least three attempted shots (with change of orientation of the cartridge in the chamber of the weapon) each cartridge with the misfires. If as a result of the first (or subsequent) impact of the striker on the Central ignition primer, a through penetration of the cap of the primer-igniter occurred without igniting the initiating composition, the experiment is terminated and a conclusion is formulated about the malfunction of the primer-igniter and the unsuitability of the cartridge for firing.

When evaluating the results of experimental firing, the following possible reasons for the absence of shots (the presence of misfires) should be taken into account: change in the physical and chemical properties of the primer-igniter (initiating composition); change in the physical and chemical properties of the propellant charge.

If necessary, the establishment of these reasons is carried out by an expert in the course of dismantling the unexpired cartridges by studying the state of the propellant charge, including the determination of the possibility of its ignition as a result of the use of a hot needle or a source of open fire.

With a satisfactory state of the propellant charge (bulk — grains do not form lumps, have a uniform color; there are no traces of ignition of the initiating composition — burnt powders, traces of thermal influence in the field of pilot hole liners, etc.) and the presence of severe outbreaks, rapid and complete combustion of when the primary supply of a red-hot needle (the source of open fire) to it, it draws conclusions about the unsuitability of cartridge for shooting due to the unsuitability for use of the initiating composition of the primer (the ignition device etc.).

In cases of slow burning, attenuation and (or) incomplete burning of the propellant charge, in the presence of traces of ignition of the initiating composition (burnt powders, traces of thermal action (soot) in the area of the fuse hole of the sleeve, etc.), the expert formulates a conclusion about the unfitness of the cartridge for firing due to the unfitness for the use of the propellant charge.

Some defects of cartridges may indicate a possible obstacle to placing in the chamber of the weapon or locking the bore when placed in the chamber of the weapon cartridge, namely:

protruding defects on the surface of the body of the sleeve (including the muzzle of the sleeve) or the leading part of the bullet, located on one side, if their value exceeds the established dimensional characteristics by 1 mm or more;

protruding defects from diametrically opposite sides on the surface of the sleeve body (including the muzzle of the sleeve) or the leading part of the bullet, if their total value exceeds the established dimensional characteristics by 1 mm or more;

defects on other structural elements of the cartridge fixing it in the chamber of the weapon (a flange, a forward cut of the case of a sleeve) if their value exceeds the established dimensional characteristics on 3 mm and more;

layering on the surface of the cartridge of foreign substances or the presence of corrosive changes (swelling of the material, including through damage), which caused a change in the thickness of the walls of the sleeve and (or) the shell of the bullet;

defects bullets (and / or) thimbles, in including dents, nadpilennye or nadrezannye shell bullets, fissures and through holes, backlash in place compounds (fastening) bullets with thimbles, "recessed" or protruding above established landing sizes bullets in thimbles.

In identifying these defects ammunition expert experiment to establish the suitability of these cartridges for firing should be conducted with weapons of the appropriate caliber. Before carrying out the experiment the expert is obliged to make attempts to remove these defects.

The provisions of the Method established that the layering of substances or corrosive changes should be tried to remove by repeated wiping with a rag, including oiled or soaked in a solvent (for example, for removing paint and varnish coatings). Point layers are removed by a single impact on them with a tool with a sharp edge (knife, scalpel, etc.). The use of sandpaper, sanding sponges, abrasive nets or abrasive tools to remove these defects is not allowed.

When removing defects, and to test the impact of the above defects on the opportunity of a shot is an expert experiment with the attempt of placing the cartridge in the chamber of weapons of corresponding caliber, locking bore and the shot.

If the experiment is successful, the expert formulates a conclusion about the suitability of cartridges for firing with the indication of conditions (for example: suitable for firing after removal of corrosive layers that prevented the cartridge from being placed in the chamber). If during the experimental shooting there were misfires, further conduct of the experiment and evaluation of its results are carried out in accordance with the above requirements.

If you cannot remove the above defects or inability of the placement of the cartridges in the chamber of weapons of the appropriate caliber or inability of locking the barrel when placed in the cartridge chamber of the weapon cartridge is formulated the conclusion about the unsuitability of ammunition for firing.

Noteworthy is the issue of the scope of the experimental study, in this case, the number of rounds to be investigated to obtain an objective conclusion. At the same time the established expert practice testifies to two approaches to the solution of the specified problem:

all objects submitted for forensic ballistic examination must be examined;

according to the previously identified features of a group of homogeneous objects, it is enough to analyze 25 % of the total volume of a homogeneous group to characterize the entire selected set of objects under study.

In addition, the decision on the number of cartridges studied in the experiment often depends on the time limit that ensures the end of the expert study in the terms established by regulatory legal acts, the availability of appropriate samples of hand-held small arms and their qualitative state, the state of the objects of study (for example, the presence of significant corrosion changes on their surface), the method of manufacturing cartridges (factory, homemade), etc.

It seems that in all cases, the determining criterion for choosing the form of the study of these objects ("solid" or selective shooting) cartridges should be the method of their manufacture.

According to provisions of a Technique at receipt for production of examination of cartridges in quantity more than 20 pieces for convenience of research and the description their division into groups is allowed. In this case, the grouping of cartridges can be carried out on various grounds, in particular the method of manufacture, design of cartridges, caliber of cartridges, type of projectile (bullet, shot or buckshot), as well as other grounds established by the Methodology.

However under conducting experimental called the shots bullets (ammunition) homemade assemble, equipped with with use of elements patrons factory assemble (teams), otstrelivayutsya in continuous order. This approach is due to the fact that each of these objects (in contrast to cartridges (ammunition) of factory manufacture) has individual criminalistically significant properties that are not regulated by technical regulatory legal acts in relation to industrial products of mass production.

Under study patrons (ammunition) factory assemble permissible their experimental shooting by an independent (random) sampling some their parts of from total number of received on study patrons one-style.

To obtain objective data on the required sample size from the group of cartridges subject to experimental shooting, the Methodology uses the Kolmogorov formula:

$$m = n\left(1 - \beta^{1/nq}\right),$$

where m — independent sample size (number of cartridges to be checked);

n — number of rounds submitted;

β — the probability of missing an unsuitable cartridge (accepted β=0.05–0.1);

q — the probability of choosing an unsuitable cartridge for firing (accepted q=0.05–0.1).

Table 3.6.1 — **Ratio of the number of cartridges to be shot**

No.	**Number of cartridges submitted for research, PCs.**	**The minimum number of rounds that must be shot, %**	**The maximum number of rounds that must be shot, %**	**The number of rounds that you want to shoot, PCs.**
1	10	90	99,7	9–10
2	15	75	97	12–15
3	20	68	95	14–19
4	30	53	87	16–26
5	40	45	78	18–31
6	50	37	70	19–35
7	60	32	63	19–38
8	70	27	57	19–40
9	80	25	53	20–42
10	90	22	49	20–44
11	100	21	45	21–45
12	110	19	42	21–46
13	120	17,5	39	21–47

If at selective shooting of cartridges of one group there was a misfire, shooting of the remained cartridges of homogeneous group is made in a continuous order.

However the above formula is applicable only for the number of not more than 150 pieces of checked cartridges of one sample. At receipt on research from 151 to 1000 cartridges of one sample experimental shooting is made on the basis of 10 percent sample from quantity of the cartridges arrived on research (but not less than 50 pieces). When more than 1000 cartridges of one sample are received for the study, the experimental shooting is carried out on the basis of a 5 % sample of the number of cartridges received for the study (but not less than 100 pieces).

In case of receipt of a significant amount of cartridges (ammunition) with corrosive changes for the study, all objects should be cleaned. After carrying out the experiment on placing the cartridge in the bore and establishing the possibility of locking it, all such cartridges or their sample, calculated by applying the Kolmogorov formula, are shot (if their number goes beyond the obtained interval in the direction of increase) [136; 141; 162].

For example, the study presented 120 rounds with corrosion changes on the bullets and sleeves. In accordance with data tables 12 should shoot group patrons volume of from 21 until 47 units. After cleaning and checking the possibility of placing in the chamber and locking the bore of the group was 55 pieces. In this case, it is necessary to shoot 21–47 rounds, and in the case of a misfire in the production of experimental shooting — and the remaining cartridges. If it is impossible to obtain as a result of cleaning a 10-percent sample when entering the study from 151 to 1.000 rounds of one sample (less than 50 rounds) or a 5-percent sample when entering the study more than 1.000 rounds of one sample (less than 100 pieces), the firing of the obtained group of cartridges should be carried out in a continuous order.

This approach, enshrined in the Methodology, allows during the production of forensic ballistic examination with the necessary reliability and sufficiency to determine the state of the objects of research of factory and homemade manufacture, as well as to qualitatively determine their properties, reduce time-consuming costs in the production of examination, increase the resource of hand-held small arms used in experimental shooting.

Measurement of energy characteristics of the thrown element is carried out for the purpose of establishment of conformity of cartridges of self-made production, including the reloaded, to criterion of intended purpose for defeat of the purpose. The experiment is carried out with the use of weapons designed to fire a cartridge of the appropriate type (type, caliber), and devices for measuring the speed of projectiles.

In practical expert activities are often investigated cartridges (ammunition) for rifled firearms, peresnaryazhennye homemade way using elements of cartridges (ammunition) factory production. Conclusion about suitability such patrons (ammunition) for called the shots and destruction goal is formulated in conclusion forensic-ballistic expertise on the basis their experimental shooting and calculation energy performance.

So, on judicial-ballistic research the cartridge found during carrying out survey of a scene arrived. This cartridge was compared with the description and graphic images of cartridges for hand firearms, placed in the manual edited by M. M. Blum and A. I. Ustinov “cartridges of hand firearms and their forensic investigation” [202, p. 41]. As a result, it was found to coincide with the 9×18 Mak cartridge, which is ammunition for the Makarov pistol, the Stechkin automatic pistol and other rifled firearms of 9 mm caliber manufactured for this cartridge. Matches are established by the form, dimensional characteristics of the elements and the device of the cartridge.

At the same time, it was established that the following changes were made to the design of the cartridge submitted for study:

lower (1.8 mm) fit of the bullet compared to the size characteristics for the cartridge 9×18 Mak, manufactured industrially;

increased by 0.2 g cartridge weight;

in the cartridge case, the non-standard method instead of the primer “boxer” is installed the primer “Zhevelo”, used when equipping hunting cartridges.

On the basis of the conducted research, the expert concluded that the specified munition was made by a homemade method (reloaded) using elements of the 9×18 Mak cartridge of factory manufacture (bullets and sleeves), the “Zhevelo” capsule and the propellant charge. It was not possible to determine the type of propellant charge in the course of the study due to the complexity of disassembling the specified cartridge and the lack of appropriate technical means.

A sample of the weapon for firing from which was designed the cartridge, the study was not submitted. In order to resolve the issue of the suitability of this object for shooting with a measurement in the index, it was shot from a 9-mm pistol IZH-71-18E, for which the cartridge 9×18 Mak is a regular.

During the experimental shooting, it was found that:

the shot occurred after the first blow of the striker on the primer without any misfires or delays with a weak sound of the shot;

the bullet lodged in the bore;

the cartridge case is not ejected out through the bolt window, wedged between it and the breech section of the barrel.

The analysis of the experimental shooting showed that the main reasons for this result could serve as:

the use of a non-standard slow-burning propellant charge in the cartridge under study, as a result of which the forcing pressure during the shot did not reach the required value;

firing a weapon, the automation of which is based on the recoil of the free bolt, locking the barrel bore in which is determined by the force of the return spring, the mass of the bolt and the sliding friction forces between the moving parts.

As is known, the principle of recoil of the free bolt is the basis of the Mak gun automatics. In the process production shot being fired gunpowder gases act simultaneously on bullet, on the walls and bottom thimbles, in a result what the latter component forces ceded the bolt. At the same time there are several multidirectional forces:

the pressure force of the powder gases tends to throw the projectile element (bullet) from the bore;

the pressure force on the bottom of the sleeve pushes it back from the chamber, overcoming the inertia of the shutter, the friction of the walls of the housing shells on the surface of the chamber and the force of compression return spring.

As a result of the simultaneous impact of these forces, the methane the element and the sleeve, held in the bolt ejector, begin to move in opposite directions, but at different speeds: if the speed of the bullet near the muzzle reaches 315 m/s, the maximum shutter speed usually does not exceed 4–5 m/s (for regular cartridge). In this case, the Mak design provides a condition in Which the bolt at the time of firing (before the bullet leaves the barrel channel) departs some distance from the breech section of the barrel (<3 mm), since the pressure on the bottom of the sleeve will be higher than the pressure acting on the bottom of the bullet (figure 3.6.1) [251, pp. 82–83].

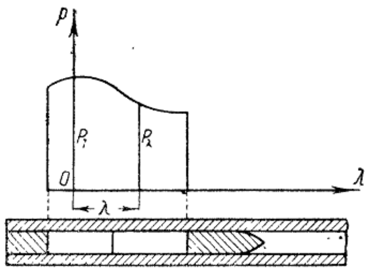


Figure 3.6.1 — **Pressure Distribution of powder gases in the discharge space in the preliminary and first periods of the shot**

Under normal conditions, the bullet leaves the bore, and the bolt ejector moves back, removing the sleeve from the chamber. In the studied case, at a certain point in time, when the sleeve will pass a distance of about 2 mm, the pressure of powder gases in the discharge space will reach a certain limit value, at which the pressure will be released through the gap between the cartridge case, not expanded when fired, and the chamber wall (in a slightly worn barrel Mak — 0.8 mm) and, as a consequence, the bullet will acquire a lower velocity.

This hypothesis was confirmed by the results of experimental firing from the Mak, in the chamber of which there was a through hole with a diameter of 5 mm. The reset pressure of the powder gases through the said hole the pistol did not work in normal mode, and the average velocity for ten rounds was 127 m/s (the data were rounded to whole numbers).

The average value of the velocity v_{mean} is determined by the formula:

$$v_{mean} = \sum_{i=1}^{10} v_i / 10$$

Shot	1	2	3	4	5	6	7	8	9	10
Velocity, m/s	120	144	122	127	121	125	124	131	127	132

$$v_{mean} = \frac{120+144+122+127+121+125+124+131+127+132}{10} = 127\ (m/s).$$

These circumstances in the application of non-standard propellant charge and a relative movement of parts of weapons don't allow to create in the moment of firing, the pressure forcing in senaratna space where the bullet would leave the barrel before the cartridge case from the chamber and the pistol would work in a regular mode.

Given the above, it appears that to improve the efficiency of forensic ballistic research ammo (ammunition) to rifled firearms equipped in a makeshift way using ammo items factory manufacturing when failure or lack of a specific instance of the weapon for firing from which was manufactured the cartridge (ammunition), it seems appropriate to recommend experts for the admission of patrons to the design features and dimensional characteristics to the standard sample manual strelkovogo firearms, using in its design the principle of rollback of the free gate:

to make shooting of the specified cartridges from the samples of the weapon providing locking of the channel of a trunk by the fixed lock, or ballistic installation;

to provide a fixed fixation of the bolt of the substitute weapon in order to reliably lock the bore and create a sufficient level of pressure in the bore when fired [131].

Despite the fact that in terms of expert departments during the pilot shooting of rounds (ammunition) a weapon is used, the substitute options and breech of the barrel which correspond to the dimensional characteristics of the cartridge, in our opinion, this approach is debatable. In industry, for example, under conducting ballistic tests patrons (ammunition) to small arms (in including pistol) are used ballistic installations with longitudinally-sliding the bolt, locking canal trunk in which ensured zatsepleniem projections larvae the bolt with receiver box, than are achieved immobility the bolt and reliability locking canal trunk in moment production shot being fired under conducting tests [18].

At research of the cartridges made by a self-made way, including peresnaryazhennyh, together with self-made or converted weapon which parameters of a chamber correspond to parameters of cartridges, energy characteristics of cartridges are defined on the basis of results of their shooting from the presented copy of the weapon.

In the production of a series of shots to measure the energy characteristics of the projectile between the individual shots in the series must be paused for at least 2 minutes, it is necessary to make sure that there are no elements in the bore of the cartridge (wads, gaskets, etc.), used for the production of the previous shot. The bolt of the weapon (bolt frame with bolt) is thus installed in the extreme rear position and must be held in such a way that the barrel bore remains open both from the muzzle and from the breech. This provision of the Methodology is intended to ensure both the safety of the person performing the examination and the relative constancy of the ballistic characteristics of the throwing element during experimental firing due to the heating of the barrel of the weapon.

After the measurement of speed of flight of the projectile throwing expert is defined by its kinetic energy (E) according to the formula:

$$E = \frac{mV^2}{2} \text{(J)},$$

where m — projectile weight (kg);

V — projectile velocity (m/s).

Then the calculation of the cross-sectional area (S) of the projectile is carried out according to the formula:

$$S = \frac{\pi D^2}{4} \text{ (mm}^2\text{)},$$

where π = 3.14 (constant);

D — diameter of projectile (mm).

Then the specific kinetic energy (E_y) of the thrown element is calculated by the formula:

$$E_y = \frac{E}{S} \text{ (J/mm}^2\text{)}.$$

In this case, the values of the results obtained when calculating the values (*E*), (*S*), (E_y), are rounded to hundredths.

If the obtained value of the value of the specific kinetic energy of the projectile $E_{spec.} \geq 0{,}5$ J/mm^2, this means that the cartridge is suitable for firing, meets the criterion of intended purpose to hit the target and belongs to the category of ammunition.

If the value of the specific kinetic energy of the projectile is less than 0.5 J/mm^2, this indicates that the cartridge does not meet the criterion of intended purpose for hitting the target, and therefore does not belong to the category of ammunition.

In the final stage of the expert study is carried out evaluation on the stages of preliminary and detailed research results, formulate the final conclusions in summary form that reflects the essence of the obtained results — the assignment (notesini) presents cartridges to the category of ammunition, small firearms, as well as a statement of fact suitability (unsuitability) for shooting them.

The Methodology contains a provision that the conclusion about the impossibility of solving the issue on placing a cartridge improvised the category of munitions and the establishment of the state of its suitability for shooting is formulated in the following cases: impossibility of definition of the size (sample, model) of the weapon for firing is applied to the study of the cartridge, or the lack of the ability production of the expert experiment.

Thus, the following conclusions can be formulated on the basis of what is stated in this section.

1. The methodology of criminalistic research of cartridges for hand small arms, the establishment of suitability for firing refers to the model type of methods, i. e. represents a method of expert solutions to com-

mon tasks, and is an expression of the generalized practical experience, expertise rounds (ammunition), which includes the following stages: preliminary study, detailed study, comparative study (including expert experiment), evaluation of research results and formulation of conclusions.

2. The scientific approaches fixed in the specified Technique are directed on the decision of the classification and diagnostic problems connected with expert research including the cartridges used for firing from manual small arms, obtaining necessary data on properties of the investigated objects, their reference to category of ammunition, determination of their suitability for firing, provide reliability of results of expert research and their representativeness.

CONCLUSION

The presented monography is devoted to topical issues of forensic activities of forensic research of cartridges (ammunition) used for shooting in hand-held firearms. In the text of the work, the theoretical and practical aspects of the study of criminalistically significant properties of these objects, including their historical development, are gradually revealed.

The most significant of them, according to the authors, are as follows. In the monography for the first time various approaches to definition of the term "ammunition" in various branches of knowledge are investigated: legal, military, technical. At the same time, it is noted that in law enforcement and expert practice at the moment there is no unambiguous understanding of the essence of this term, which is due to the different spheres of its application. As a result of clarification of the basic signs characterizing the specified object, the conclusion that the definitions of the term "ammunition" contained in scientific literature and normative legal acts are characterized by uncertainty regarding fixing of its signs in this connection do not fully meet the needs of criminalistic research of such objects is proved.

To overcome this problem, the author formulated and theoretically justified the definition of the term "small arms ammunition", based on the results of understanding the essential aspects of the forensic study of ammunition, including the main features characterizing their structural and functional properties.

The proposed definition reflects the following distinctive features: functional purpose, structural security, multicomponent, single use, the effect on the target of a sufficient level of damaging properties of the projectile element of the munition.

Lack of unambiguous understanding and uniform application of criteria of reference of the cartridges used for firing from manual small arms, to category "ammunition", complexity in definition of constructive and functional properties of the investigated objects caused need of development of exact and scientifically proved criteria of reference of cartridges to the specified category. These criteria include: multicomponent, single-use, the suitability of the cartridge for firing. For homemade and improvised reequipped way of bullets (ammunition) in addition a criterion for the purpose of hitting the target.

The use of these criteria allows to provide unity of approaches in the production process of the judicial ballistic expertises of ammo (ammunition), complete and comprehensive investigation of structurally-functional properties of these objects, the validity and reliability of findings contributes to an objective assessment of the opinions of expert stakeholders.

In the paper the problem of classification of cartridges (ammunition) both existing samples and prospective ones is studied. Developed and scientifically based author's classification based on a comprehensive approach to the study of forensic properties of elements of the system "ammunition — weapon — target".

This classification is aimed at ensuring the effectiveness of the process of expert research of these objects, allows you to optimize the choice of methods and means of their research, corresponding to the solution of specific tasks of forensic ballistic examination, to exclude the disparity of approaches when referring a particular instance of a cartridge (ammunition) to a particular group of objects.

Considerable attention is paid to the introduction of advanced achievements in the field of obtaining criminally significant measuring information into forensic activities. So, in particular, in the process of determining the model and the specific instance of the weapon from which the bullet is fired, the set of linear-angular parameters of the traces displayed on the elements of the cartridge (ammunition) is measured).

In the framework of the study conducted by the author developed and tested PAK "BIZAN", designed to measure the linear and angular parameters of traces of weapons on the elements of the design of cartridges (ammunition), the principle of operation of which is based on the correlation analysis of digital stereo images. The approach based on partial modernization of microscopic equipment available in expert units was used in the development of this measuring instrument.

In addition, the issues of tool support of the production of forensic ballistic tests of cartridges (ammunition) with the conditions of the pilot shooting, selection of the necessary technical means, determining the qualitative state of small firearms, means of measuring the speed of throwing item, matching the results obtained from the point of view of Metrology.

In the framework of the theoretical and experimental study, the author refined the criterion of the minimum striking ability of a single wounding projectile used as a criterion of the striking ability of small arms in forensic ballistics. The empirical data obtained as a result of experimental firing indicate that the currently used value of the specific kinetic energy of a single propellant element 0.5 J/mm^2 needs to be reduced to a value of 0,35 J/mm^2.

The article analyzes both from theoretical and practical positions the technique of forensic investigation of small arms cartridges, their serviceability and suitability for use for the intended purpose, which was used earlier in the production of forensic ballistic examinations and studies (2008). In the course of the study, it was found that the above-mentioned technique did not fully meet the requirements of modern practice of expert research of cartridges (ammunition). On the basis of advanced achievements in the field of forensic ballistics, information from related branches of science, the principle of consistency is used in the development of the current Methodology, which allows to objectively establish the properties of the studied object both in the aggregate and in isolation.

The implementation of the provisions enshrined in the Methodology allows to refer the cartridge to the category of "ammunition" on the basis of the identified structural and functional properties, to determine its suitability for hitting the target as a result of firing, thereby ensuring the validity of the results and the reliability of the conclusions formulated in the expert's opinion.

The results of the study reflected in this work, according to the authors, can be used for further theoretical and applied research in forensic science and forensic ballistic examination, law enforcement practice.

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